BIOLOGICAL CHARACTERISTICS OF ATLANTIC SALMON (Salmo salar L.) IN THE UPPER LAHAVE RIVER BASIN

R.W. Gray[1]

Department of Fisheries and Oceans
Scotia-Fundy Region
Fisheries Research Branch
Freshwater and Anadromous Division
P.O. Box 550, Halifax, N.S. B3J 2S7

[1]Present Address: Department of Fisheries and Oceans
Gulf Region, Fisheries Research Branch
Freshwater and Anadromous Division
P.O. Box 5030, Moncton, N.B. E1C 9B6

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Department of Fisheries and Oceans
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P.O. Box 550, Halifax, NS B3J 2S7

[1]Present Address: Department of Fisheries and Oceans, Gulf Region, Fisheries Research Branch, Freshwater and Anadromous Division, P.O. Box 5030, Moncton, NB E1C 9B6

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CONTENTS

LIST OF TABLES iv

LIST OF FIGURES v

ABSTRACT/RÉSUMÉ vii

INTRODUCTION 1

MATERIALS AND METHODS 1

RESULTS AND DISCUSSION 4

- Smolt Age 4
- Saltwater Age 5
- Size Characteristics in Relation to Age 5
- Length/Weight Relationship 6
- Salmon:Grilse Ratio 6
- Sex Ratio 7
- Fecundity 8
- Fish Migration and Timing 8
- Migration Routes 9
- Stray Rate 10
- Angling Exploitation Rate 10
- Commercial Exploitation Rate 11

SUMMARY AND CONCLUSIONS 11

ACKNOWLEDGEMENTS 12

REFERENCES 13

LIST OF TABLES

TABLE 1. Morgan Falls trap operation periods, timing and duration of the migration, and numbers of salmon counted 15

TABLE 2. Proportion of salmon sampled at Morgan Falls prior to their release upstream for natural spawning 16

TABLE 3. Smolt-age composition of 1SW and MSW salmon in relation to stock origin at Morgan Falls, 1974-81 17

TABLE 4. Freshwater and saltwater age composition of wild and hatchery-return salmon sampled at Morgan Falls, 1974-81 18

TABLE 5. Composition of returning salmon in relation to age of wild and hatchery-reared smolts, 1974-81 19

TABLE 6. Size characteristics in relation to age and stock origin of Atlantic salmon released above Morgan Falls for natural spawning, 1978-81 20

TABLE 7. Condition factors (K) of 1SW and 2SW salmon in relation to stock origin at Morgan Falls, 1978-81 21

TABLE 8. T-statistics obtained by comparing the mean fork lengths, weights and condition factors of wild and hatchery-return 1SW and 2SW salmon sampled at Morgan Falls, 1978-81 22

TABLE 9. Length-weight relationships for wild and hatchery-return 1SW and 2SW salmon sampled at Morgan Falls, 1978-81 23

TABLE 10. Salmon:grilse and sex ratios of wild and hatchery-return salmon sampled at Morgan Falls, 1978-81 24

TABLE 11. Proportion of LaHave salmon destined to mature as 1SW and 2SW or older salmon based on the release of tagged hatchery-reared smolts 25

TABLE 12. Fecundity data collected from small numbers of salmon broodstock captured in three Nova Scotia rivers, 1980-81 26

TABLE 13. Recapture of Atlantic salmon at various locations from 54,008 hatchery-reared smolts tagged and released in the LaHave River, 1974-79 27

LIST OF FIGURES

FIG. 1. Map of the LaHave River watershed showing the major lakes, tributaries, obstructions and location of the Morgan Falls fishway trap 28

FIG. 2. Morgan Falls fishway and trapping facilities used to sample the upper basin salmon stock 29

FIG. 3. Length-weight relationship for 1SW salmon of wild and hatchery-return origin, 1978-81 30

FIG. 4. Length-weight relationship for 2SW salmon of wild and hatchery-return origin, 1978-81 31

FIG. 5. Fecundity-length relationship for LaHave-Medway 2SW salmon 32

FIG. 6. Number and timing of wild and hatchery-return 1SW salmon at Morgan Falls in relation to water temperature and discharge - 1978 33

FIG. 7. Number and timing of wild and hatchery-return MSW salmon at Morgan Falls in relation to water temperature and discharge - 1978 34

FIG. 8. Number and timing of gaspereau and lamprey at Morgan Falls in relation to water temperature and discharge - 1978 35

FIG. 9. Number and timing of wild and hatchery-return 1SW salmon at Morgan Falls in relation to water temperature and discharge - 1979 36

FIG. 10. Number and timing of wild and hatchery-return MSW salmon at Morgan Falls in relation to water temperature and discharge - 1979 37

FIG. 11. Number and timing of gaspereau and lamprey at Morgan Falls in relation to water temperature and discharge - 1979 38

FIG. 12. Number and timing of wild and hatchery-return 1SW salmon at Morgan Falls in relation to water temperature and discharge - 1980 39

FIG. 13. Number and timing of wild and hatchery-return MSW salmon at Morgan Falls in relation to water temperature and discharge - 1980 40

FIG. 14. Number and timing of gaspereau and lamprey at Morgan Falls in relation to water temperature and discharge - 1980 41

FIG. 15. Number and timing of wild and hatchery-return 1SW salmon at Morgan Falls in relation to water temperature and discharge - 1981 42

FIG. 16. Number and timing of wild and hatchery-return MSW salmon at Morgan Falls in relation to water temperature and discharge - 1981 43

FIG. 17. Number and timing of gaspereau and lamprey at Morgan Falls in relation to water temperature and discharge - 1981 44

FIG. 18. Location of tag recaptures from tagged hatchery-reared salmon smolts released above Morgan Falls, 1974-79 . . . 45

ABSTRACT

Gray, R. W. 1986. Biological characteristics of Atlantic salmon (Salmo salar L.) in the upper LaHave River basin. Can. Tech. Rep. Fish. Aquat. Sci. No. 1437.

Atlantic salmon were enumerated and sampled in a fishway trap located at Morgan Falls, an impassable natural falls on the main branch of the upper LaHave River. Biological characteristics of wild salmon are described including: smolt age, saltwater age, size, length/weight relationship, salmon:grilse ratio, sex ratio, fecundity, run timing, migration routes, stray rate and exploitation rates. Ninety-one percent of the virgin salmon sampled had a smolt age of two years; 6.8% were three years old. Saltwater age of salmon consisted of 78.1% 1SW salmon and 21.8% 2SW salmon. Mean fork length and mean weight of 1SW salmon was 54.0 cm and 1.638 kg, respectively; wild, 2SW salmon had a mean fork length and weight of 72.4 cm and 4.152 kg, respectively. Length/weight relationships for 1SW and 2SW salmon were: weight = $0.0000597\ FL^{2.5587}$; weight = $0.0000129\ FL^{2.9580}$, respectively. Two sea-winter salmon were 67.8% female; 1SW salmon were 30.9% female. Salmon movements at Morgan Falls were stimulated by increased discharge but impeded in the fishway when large numbers of gaspereau or lamprey were present. Stock characteristics of hatchery-return salmon are described and compared to those of wild salmon. Tagged hatchery-return salmon exhibited a stray rate of 1.2%. Adjusted angling exploitation rates for 1SW and 2SW hatchery-return salmon were 23.6% and 22.7%, respectively. Minimal exploitation rates for LaHave salmon in Greenland, Newfoundland and Nova Scotia commercial fisheries are presented.

Key Words: Atlantic salmon, age, size, length/weight relationship, sex ratio, fecundity, salmon:grilse ratio, run timing, migration routes, stray rate, exploitation rate.

RÉSUMÉ

Gray, R. W. 1986. Biological characteristics of Atlantic salmon (Salmo salar L.) in the upper LaHave River basin. Can. Tech. Rep. Fish. Aquat. Sci. No. 1437.

Les saumons ont été comptés et échantillonnés à la passe migratoire des chutes Morgan, une chute impraticable de la branche principale de la rivière LaHave. Les caractéristiques des saumons sauvages qui sont décrites ici incluent: l'âge des saumoneaux, l'âge en mer, la taille, le rapport longueur-poids, rapport saumons-madeleineaux, proportion des sexes, fécondité, époque de la montaison, routes de migration, taux d'égarement et taux d'exploitation. Des saumons vierges échantillonnés, 91% avaient été saumoneaux à deux ans et 6.8% à trois ans. Les retours comprenaient des unibermarins dans la proportion de 78.1% et 21.8% de

saumons dibermarins. La longueur à la fourche et le poids moyens des unibermarins étaient de 54.0 cm et 1.638 kg respectivement; les dibermarins sauvages avaient une longueur à la fourche et un poids moyens de 72.4 cm et 4.152 kg respectivement. Les relations longueur-poids des saumons unibermarins et dibermarins étaient les suivantes: poids = $0.0000597\ LF^{2.5587}$; poids = $0.0000129\ LF^{2.9580}$ respectivement. Les saumons dibermarins comprenaient 67.8% de femelles; les unibermarins, 30.9% de femelles. Une augmentation du débit stimulait les déplacements des saumons aux chutes Morgan, mais la présence de grands nombres de gaspareaux ou de grandes lamproies marines causait un ralentissement. Les caractéristiques des retours de saumons de pisciculture sont décrites et comparées à ceux des saumons sauvages. Les premiers, marqués, ont un taux d'égarement de 1.2%. Les taux ajustés d'exploitation par pêche sportive des saumons de pisciculture unibermarins et dibermarins étaient de 23.6% et 22.7% respectivement. Les taux minimaux d'exploitation des saumons de la rivière LaHave dans les pêcheries du Groenland, de Terre-Neuve et de la Nouvelle-Ecosse sont présentés.

Mots-clés: saumon de l'Atlantique, âge, taille, rapport longueur-poids, proportion des sexes, fécondité, rapport saumons-madeleineaux, époque de la montaison, routes de migration, taux d'égarement, taux d'exploitation.

INTRODUCTION

The LaHave River flows southeast through the Nova Scotia counties of Lunenburg, Kings and Annapolis to the Atlantic Ocean at Bridgewater. Its drainage area is approximately 1,668 km^2, and its watershed includes 113 lakes having a total surface area of 7,515 hectares. The river has a meander length of 92 km with five major tributaries - West Branch, North Branch, Main Branch, Ohio River and North River (Fig. 1).

In 1970, an Atlantic salmon (Salmo salar L.) development project was initiated on the LaHave River. The salmon, gaspereau (Alosa pseudoharengus [Wilson]), lamprey (Petromyzon marinus L.), shad (Alosa sapidissima [Wilson]), and speckled trout (Salvelinus fontinalis [Mitchill]) migrations have been monitored annually at Morgan Falls since 1970. The salmon development project, stream characteristics, water quality and spawning and nursery habitat have been described elsewhere (Gray 1974; Gray 1986; Gray et al. 1986). An assessment of the status of salmon stocks in the LaHave River was made by Cutting and Gray (1984).

This report describes the biological characteristics of the upper-basin salmon stock which developed from hatchery plantings. Comparisons between hatchery-return salmon and resultant progeny from salmon which have spawned naturally above Morgan Falls since 1970 are summarized. Data on age, size, condition, sex ratio, fecundity, salmon: grilse ratio, magnitude and timing of migration, and migration routes are presented.

MATERIALS AND METHODS

Atlantic salmon and other species were monitored at a fishway trap located at Morgan Falls, an impassable barrier to fish migration. Complete fish counts were possible since upstream migrants had to utilize a vertical slot fishway to bypass the falls. The fishway trap was operated annually from early May to early November; trapping was discontinued when the salmon run diminished to zero in late October or early November (Table 1).

The Morgan Falls trap was built to slide vertically inside a wooden frame which was equipped with a mechanical hoist to raise or lower it (Fig. 2). Overall trap dimensions were 244 cm x 198 cm x 183 cm. Side panels were constructed of 51 mm x 102 mm framing with vertical 25 mm x 76 mm slats at clear spacings of 16 mm. Bottom panels were similar in bar slat size and clear spacings. A V-trap funnel was constructed on one side of the trap, and was butted against the fishway exit pool to

prevent fish from escaping. The funnel opening tapered from 61 cm to 20 cm over a distance of 61 cm. Bar slats, 25 mm x 76 mm, were placed horizontally in the V-trap funnel; a sliding vertical panel was fitted to the narrowest section of the funnel so that it could be closed to permit examination of trapped fish. The trap exit gate was 61 cm x 198 cm and was equipped with a vertical sliding panel with similar bar size and clear spacings[1].

Since the magnitude and composition of the salmon run varied from year to year, sampling protocol also changed (Table 2). All broodstock were sampled at the trap unless water temperature exceeded 20°C or if a fish was in poor condition due to net marks or other injuries.

Atlantic salmon were dipped from the trap and carefully placed in a live box located on a platform scale containing a predetermined weight of water. Live weight was determined to the nearest 1.0 g. Fork length was measured to the nearest 0.1 cm by a metre stick built into the back wall. Scales were removed from the left side of the fish in the area midway between the dorsal fin and lateral line. Scales were later mounted on glass slides and aged at 40X magnification with a Bausch and Lomb microprojector.

Length, weight and age data were collected from 1,651 adult salmon sampled at the Morgan Falls fishway from 1974 to 1981. However, because salmon returns were of predominantly Medway River parentage from 1974 to 1977, only size characteristics for the later period, 1978-81, representing returns from broodstock collected at Morgan Falls, are presented in this paper. Means, standard deviations and ranges for length and weight, according to stock origin and freshwater and marine age, were calculated. For salmon sampled between 1978 and 1981, condition factors were calculated according to age class and stock origin. T-test statistics were used to compare mean lengths, weights, and condition factors of wild and hatchery-return salmon.

Data from 1978 to 1981 were combined to derive length/weight relationships for 1SW and 2SW hatchery-return and wild salmon. The logarithmic expression of the regression $W = aFL^b$, i.e., $\ln W = \ln a + b(\ln FL)$, was used to calculate length/weight relationships; these were compared by analysis of covariance as described by the General Linear Model (GLM) of SAS.

All salmon were sexed externally. Sexing after July 31 was assumed to be accurate in this study since subtle changes in secondary sex characteristics, such as head and jaw configurations were evident to the

[1]Details of trap design can be obtained from drawing M-C-927 dated July 1971, Engineering Section, Freshwater and Anadromous Division, Department of Fisheries and Oceans, P.O. Box 550, Halifax, N.S.

samplers. This assumption was confirmed by a small grilse sub-sample of ten fish examined on July 31, 1980. Sexing error prior to July 31 each year was determined from recaptures of tagged salmon which re-entered the trap and were sexed three or four times or were sexed a second time after September 1 when secondary sex characteristics were pronounced. Data from initial sexing of tagged broodstock at the trap prior to July 31 and later sexual examination of individually tagged salmon at spawning were also used. Correction factors were calculated from these data as follows:

Stock description	n	Correction factor (1978-81)
MSW females (W; HR)	123	1.15
1SW females (W; HR)	24	0.88

Sexing data collected at Morgan Falls prior to July 31 each year were adjusted by these correction factors; broodstock were excluded from the data: $FC_2 = FO_2 \times$ correction factor, where FC_2 = correct number of MSW females, FO_2 = original estimate of MSW females.

Sex ratios were calculated by expressing the numbers of females in each age group and stock as a percent of the total number of salmon in each age group and stock. Weighted means were derived for the period 1978-81.

Annual egg depositions upstream from Morgan Falls were calculated by multiplying the corrected number of females released from the trap in each age-class by the mean weight of the original salmon sexed as female and by fecundity (eggs. kg^{-1}):

(i) FC_2 X mean weight FO_2 X fecundity
(ii) FC_1 X mean weight FO_1 X fecundity

Fecundity data were collected in November 1981 during broodstock spawning operations at Coldbrook Fish Culture Station. Egg number was determined by the displacement method (Burrows 1951); egg diameters were measured by the trough method (Lagler 1952).

Salmon:grilse ratios were calculated from trap data: salmon < 63.0 cm in fork length were assumed to be grilse or 1SW salmon. This length delineation was corroborated by 841 wild fish aged between 1973 and 1981, where fewer than five salmon (previous grilse spawners) were less than 63 cm in fork length.

The magnitude and timing of the salmon runs in relation to other species, water discharge and water temperature were determined from daily records kept at the Morgan Falls fishway, and discharge records at West Northfield collected by the Inland Waters Directorate. Gray et al. (1985) describe the methodology used in collecting water temperature and discharge information. The recording period varied between years,

but generally observations were initiated in the first week of May and continued to the end of the first week in November.

The data set consisted of daily observations of the numbers of wild, hatchery-return and total 1SW; wild, hatchery-return and total MSW salmon; lamprey; gaspereau; water temperatures taken at the fishway, and discharge records at West Northfield. To allow a visual comparison of the relationship between temperature and discharge and the daily number of 1SW salmon, MSW salmon, lamprey and gaspereau at the fishway, a BASIC program was developed for the IBM personal computer - plotting was carried out with a Hewlett-Packard 7475A plotter.

A total of 54,008 tagged smolts were released above Morgan Falls from 1974 to 1979 to determine the performance of hatchery-reared progeny from different year-classes, relative exploitation rates in various fisheries and migration patterns for the LaHave stock. Although a total of 141,000 tagged smolts were released, other tagged smolts released in the river form 1971 to 1981 were used to evaluate specific hatchery experiments and hence were not included. Tag return data sent in by fishermen were not adjusted for tag loss or non-reporting.

RESULTS AND DISCUSSION

From 1974 to 1981, 1,651 salmon were sampled at the Morgan Falls fishway trap. Samples examined ranged from 126 to 474 per year, depending on stock abundance and composition. Since the trap was operated over the period of active salmon migration (Table 1), sampling data should be representative of the stock destined for the upper LaHave River basin.

SMOLT AGE

Smolt age composition of 1SW and MSW salmon of wild and hatchery-return origin is summarized in Table 3. From a total of 855 wild virgin salmon sampled between 1974 and 1981, 91.0% had smoltified at age 2 and 6.8% had smoltified at age 3; smolt age could not be determined for 2.2% of the scales (Table 4). The proportion of two year smolts in the 2SW salmon component was higher than in the 1SW component (0.957 vs 0.897); the reverse was the case for three-year smolts, 0.016 vs 0.082 (Table 3). The data suggest that a higher proportion of the younger, faster growing wild smolts mature later as 2SW salmon than as 1SW salmon (Table 5); however, the differences were not significant at $P < 0.05$.

From 796 hatchery-return virgin salmon sampled, 53.3% had smoltified after one year, 38.7% after two years, and 0.4% after three years; smolt age could not be determined on 7.6% of the samples because

of scale regeneration (Table 4). Annual variations in the proportion of one and two year smolts in both the 1SW or 2SW stock components reflect the size and numbers of juvenile salmon of each age class (0+, 1+, 2+) released. Also, the overall higher proportion of returning salmon with a smolt age of one year compared to those with a smolt age of two years (53.3 vs 38.7%) reflects the number of 1+ smolts (371,357) and 2+ smolts (68,580) released during the period 1974 to 1981 (Gray and Cameron, 1980). As observed for wild smolts, a higher proportion of the hatchery-reared 1+ smolts returned as 2SW salmon than as 1SW salmon (0.668 vs 0.452); the reverse was observed for 2+ smolts (0.231 vs 0.477) (Table 5) - these differences were not significant at $P < 0.05$.

SALTWATER AGE

The saltwater age of virgin hatchery-return salmon at Morgan Falls consisted of 63.9% 1SW, 34.8% 2SW and 1.3% 3SW (Table 4). In comparison, the saltwater age of virgin wild salmon was distributed as follows: 78.1% 1SW and 21.8% 2SW. The higher proportion of 2SW salmon in the hatchery stock component compared to the wild component (34.8% vs 21.8%) may be attributable to several factors including broodstock selection for the hatchery rearing program, differential harvesting of each stock component and the fact that the majority of hatchery-reared smolts were 1+ in age which purportedly contribute to a high proportion of 2SW salmon (Gray 1973; Ritter 1974).

During the period 1974 to 1981, an additional 79 wild previous spawners and 43 hatchery-return previous spawners were sampled. In relation to the total wild sample, wild previous spawners represented 8.5% of the stock. In comparison hatchery-return previous spawners made up 5.1% of the total hatchery-return stock.

SIZE CHARACTERISTICS IN RELATION TO AGE

Size characteristics in relation to age and stock origin of salmon released upstream at Morgan Falls are summarized in Table 6. Data from samples collected during 1978-81 are more appropriate in present stock considerations because of their parental stock origin. Mean fork lengths and weights of wild and hatchery-return 1SW salmon were 54.0 cm, 1.638 kg and 53.5 cm, 1.546 kg, respectively. Two sea-winter salmon of wild and hathery-return origin had mean fork lengths and weights of 73.1 cm, 4.250 kg and 73.4 cm, 4.278 kg, respectively (Table 6).

Condition factors for 1SW and 2SW salmon of wild and hatchery origin are summarized in Table 7. With the exception of hatchery-return 1SW salmon in 1980-81, all other salmon regardless of age or stock origin had mean condition factors equal to or greater than 1.000.

Results of t-test comparisons of mean lengths, weights and condition factors indicate significant differences occur in at least one of

these parameters, between hatchery-return and wild 1SW salmon each year (Table 8). Combined data for 1978 to 1981 indicate that mean lengths, weights and condition factors of wild and hatchery-return 1SW salmon are significantly different at $P < 0.05$. No significant differences were observed between wild and hatchery-return 2SW salmon sampled over this same period.

LENGTH/WEIGHT RELATIONSHIP

Length/weight relationships calculated from data collected from 1978 to 1981 for wild and hatchery-return, 1SW and 2SW salmon are outlined in Table 9. The antilogs of these regressions were (Fig. 3-4):

1SW	-	Wild:	$W = 0.0000597FL^{2.5587}$
	-	Hatchery-return:	$W = 0.0001312FL^{2.3528}$
2SW	-	Wild:	$W = 0.0000129FL^{2.9580}$
	-	Hatchery-return:	$W = 0.0000031FL^{3.2871}$

Within the length range 50-63 cm, wild 1SW salmon are heavier than hatchery-return salmon of the same fork length. In the length range 65-75 cm, wild 2SW salmon weigh more than hatchery-return salmon of the same fork length; however, as fork length increases above 75 cm, wild and hatchery-return salmon converge in their length/weight characteristics.

Comparisons of these length/weight relationships ($\ln W = \ln a + b [\ln FL]$) were made using analysis of covariance. Significant differences ($P < 0.01$) were observed in the intercepts of the regressions for wild and hatchery-return 1SW salmon; however, the slopes were not significantly different ($P < 0.05$). Length/weight regressions for 2SW salmon of wild and hatchery-return origin exhibited no significant differences ($P < 0.05$) in either their slopes or intercepts. These results corroborate earlier findings using t-test comparisons of mean length and weight.

SALMON:GRILSE RATIO

Salmon:grilse ratios in the escapement at Morgan Falls from 1978 to 1981 are summarized in Table 10. The proportion of MSW salmon in the wild enhanced stock ranged from 0.07 - 0.20 (mean = 0.152) during this period. Failure of the 1977 smolt year class probably accounts for the low proportion of 2SW salmon in 1979. Although salmon:grilse ratios should be analyzed on the basis of their smolt-year classes, because the proportion of 2+ smolts (86.7% - 95.8%) was relatively constant each year from 1978 to 1981, the salmon:grilse ratio (0.152) calculated in this paper for the escapement is considered valid.

The proportion of MSW salmon in the hatchery-return stock exhibited a wider range from 0.09 - 0.61 (mean = 0.397) during the period 1978 to 1981. These variations were probably due to differences in annual broodstock selection criteria, differences in the number of 1+ and 2+ smolts stocked each year (Gray and Cameron 1980), failure of the 1977 smolt year class and different harvesting patterns between years. Since predominantly MSW salmon were collected as broodstock for the hatchery-rearing program, it might be expected that the hatchery component would have a higher salmon:grilse ratio than the wild enhanced stock where fewer MSW salmon were available for natural spawning during the same period.

The proportion of LaHave salmon stock destined to mature as 1SW and 2SW or older salmon is summarized in Table 11. From 54,008 tagged hatchery-reared smolts released from 1974 to 1979, 241 recaptures or 36.2% of all recaptures excluding post-smolts were reported from different locations which were destined to return as 2SW or older salmon. Comparable data from tagged smolts released from 1976 to 1979 indicate that 215 recaptures or 37.8% of all recaptures excluding post-smolts were destined to return as 2SW or older salmon. This represents a minimum value since some of the 1SW salmon recaptured in Newfoundland would also have returned as 2SW or older salmon. Salmon:grilse ratios in the various fisheries and spawning escapement based on tag recaptures were calculated (Table 11). In comparison to the salmon:grilse ratio for hatchery-return fish observed in the escapement at Morgan Falls from 1978 to 1981 (Table 10), tagging results yielded slightly lower salmon:grilse ratios - 27% and 31% for 1974-1979 and 1976-79, respectively (Table 11).

SEX RATIO

Sex ratios of MSW and 1SW salmon of wild and hatchery-return origin sampled at the Morgan Falls trap from 1978 to 1981 are summarized in Table 10. The proportion of females in wild MSW salmon ranged from 0.66 to 0.81 (mean = 0.716); hatchery-return MSW salmon ranged from 0.59 to 0.79 (mean = 0.661) female. For wild 1SW salmon sex composition ranged from 0.29 to 0.36 (mean = 0.310) female compared to a range of 0.22 to 0.30 (mean = 0.259) for hatchery-return 1SW salmon females.

Sex ratios for both wild and hatchery-return MSW salmon were not greatly different from those reported by several other authors. However, the percentage of females in both 1SW salmon components was higher than that reported for some New Brunswick salmon streams (Peppar 1983; Randall 1984; Marshall and Penny 1983), but lower than those reported for several Newfoundland streams (O'Connell and Reddin 1983). Although large numbers of grilse were sampled in this study, most of the sexing was done externally during the early part of the migration before secondary sexual characteristics were pronounced. Additional sampling of this stock is required involving internal gonadal examination to verify the sex ratio of 1SW salmon.

FECUNDITY

Data on fecundity of LaHave salmon is limited (Table 12). The only data available for 1SW salmon was derived from five wild fish collected in the Liscomb River; 1SW salmon with a mean fork length of 53.2 cm (± 1.83) produced 2,017 (± 328.4) eggs with a mean egg diameter of 5.13 mm (± 0.195).

Since the original parental stock used to rehabilitate salmon stocks in the upper LaHave basin and the headwaters of the Medway River was of Medway origin, the limited fecundity data from these broodstock were combined. Eighteen 2SW salmon with a mean fork length of 74.0 cm (± 3.36) produced 6,494 eggs (± 1601.6) with a mean egg diameter of 5.98 mm (± 0.400) and 1,473 eggs$\cdot$kg^{-1} (± 273.0). This latter value, 1,473 eggs$\cdot$kg^{-1}, was lower than fecundity values reported by some authors (Baum and Meister 1971; Elson 1975; Anon 1978), but similar to the mean relative fecundity for all Restigouche salmon comprised of 2 and 3SW salmon and previous spawners reported by Randall (1984).

Previous spawners with a mean fork length of 92.2 cm (± 1.73) produced 12,108 (± 1247.4) eggs with a mean egg diameter of 6.39 mm (± 0.407).

A fecundity-length relationship for 2SW salmon (Fig. 5) was described by the equation:

$$F = 78.799e^{0.0592FL} \qquad \text{where } F = \text{fecundity, } FL = \text{fork length (cm)}$$
$$R^2 = 0.64$$
$$n = 18$$

FISH MIGRATION AND TIMING

As expected, the LaHave River exhibits an inverse relationship between water temperature and discharge during the May to November period. Data on numbers of fish and timing of salmon movements in relation to temperature, disharge and other species are presented in Figs. 6-17.

No obvious differences in run timing exist between hatchery-return and wild 1SW salmon (Figs. 6-17). The 1SW salmon migration consists of an early and late peak. The first 1SW salmon run begins in mid-June coinciding to the end of the lamprey and gaspereau runs; it peaks in early to mid-July and diminishes during the low flow period in August. In most years, the 1SW salmon migration begins again in mid-September to Mid-October and correlates with increased discharge. This latter migration is not considered a "late" run stock component since these fish have been in the river for some time and are dark in coloration - very few have sea lice or are bright in coloration. It is assumed that these fish enter freshwater in late July or early August and hold in the lower river reaches because of low discharge.

Multi-sea-winter salmon also exhibit early and late migration peaks; on cursory examination no differences in run timing between hatchery-return and wild fish were observed (Figs. 6-17). The data shows that the early migration of MSW salmon begins about mid-May; however, the major portion of the run reaches Morgan Falls near the end of the lamprey and gaspereau runs in mid June, peaks in mid to late June and diminishes during the summer low flow period. The later migration of MSW salmon coincides with the late 1SW salmon peak beginning in mid-September to mid-October when discharge increases. It declines rapidly and ceases by early November. As described previously for the 1SW salmon component, this later migration peak is not considered as a "late" run component, but rather a migration of fish which enter freshwater in early summer and remain in the lower pools or in Wentzell's Lake before moving upstream in response to increased discharge. This is corroborated by data from 1979, a year of unusually high discharges, when both 1SW and MSW salmon entered freshwater in early summer and exhibited continuous upstream movements from June to October in response to freshets (Figs. 9-10).

Hayes (1953) operated a counting fence 1.6 km above the head of tide on the LaHave River from 1950-51. Timing of 1SW and MSW salmon migration described in this paper is similar to that reported by this author.

Run timing of both 1SW and MSW salmon at Morgan Falls was positively correlated with discharge, but impeded in the fishway by the presence of large numbers of gaspereau or lamprey. Water temperature appears to have less influence on the upstream migration of salmon since water temperatures are moderate (< 21°C) when fish enter freshwater. Although an attempt was made to statistically analyze the relationship between salmon movements, discharge, water temperature and other species in the fishway such as lamprey and gaspereau, these relationships were confounded by problems with fish availability, threshold levels in discharge and water temperature affecting movements, and therefore were not dealt with in this paper. However, fish movements influenced by increased discharge described here corroborate earlier findings (Huntsman 1945; Hayes 1953; Alabaster 1970).

MIGRATION ROUTES

Tag returns from 54,008 1+ and 2+ hatchery-reared LaHave salmon smolts released above Morgan Falls from 1974 to 1979 were used to determine migration routes (Table 13; Fig. 18).

Smolts emigrate in mid-May and are taken in Nova Scotia coastal waters such as St. Margaret's Bay in early June. Tag recaptures from mid-June of the year of stocking until one year later when salmon are separated spatially into two components, grilse and MSW salmon, are sparce.

Fish destined to return as 1SW salmon are taken predominantly as a by-catch along the Nova Scotia coast from Richmond County, Cape Breton to St. Margaret's Bay; recaptures were made from the latter part of June to the first week of July in the year following stocking. Although few tag recoveries were reported from the Eastern Shore (NS), it is probable that more 1SW salmon are taken in this area than are reported (Gray et al. 1980).

Salmon destined to return as 2SW or older salmon appear to move north along the east coast of Newfoundland from mid-June to mid-July in the year following stocking. A few tags have been reported from southern Labrador in late July and 1SW salmon appear to enter the Greenland fishery in early August, one year after their release as smolts. Several recaptures of 2SW salmon on their return to their natal streams have been reported from mid to late May along the east coast of Newfoundland. However, the majority of the 2SW salmon recaptured were reported from late April to late June in homewaters from Herring Cove to Green Bay at the mouth of the LaHave River. As indicated in Table 13, few tag recoveries from 2SW salmon were made in Atlantic Cape Breton or along the Eastern Shore; one recovery was made at Halls Harbour in the Bay of Fundy. Since over 80% of the tag recoveries from 2SW salmon in homewaters were reported from May 1 to June 15, these data corroborate information presented earlier in this paper on upstream migration timing.

The total unadjusted tag recapture rate from all fisheries and spawning escapement was 1.28%. This recapture rate represents a minimal value for the stock since it is not corrected for tag loss, differential mortality between tagged/untagged smolts or non-reporting of tagged salmon. It is also difficult to obtain accurate information on timing since recaptures are dependent on fishing seasons which vary annually according to prescribed fishing plans.

STRAY RATE

Based on the tagging data in Table 13, the stray rate of hatchery-return salmon was 1.2% assuming the four tags reported from other rivers represented the same proportion of the river escapement as those on the LaHave and that the two tag recoveries from the Bay of Fundy were indeed "lost" salmon.

ANGLING EXPLOITATION RATE

Angling exploitation of 1SW salmon in the LaHave River was 17.8% compared to 17.1% for MSW salmon (Table 13). If these data are adjusted upwards to account for 30% non-reporting of tagged fish, the adjusted angling exploitation rates for 1SW and MSW salmon were 23.6% and 22.7% respectively. The total adjusted exploitation rate by anglers for this enhanced stock was 23.3%.

COMMERCIAL EXPLOITATION RATE

Lack of data on tag reporting efficiency in the various commercial fisheries preclude adjustments to derived commercial exploitation rates from Table 13. Total exploitation in all commercial fisheries was 32.1% distributed as follows in relation to total tag recaptures: Greenland (9.0%); Newfoundland (7.1%); and Nova Scotia (16.0%). These represent minimal values for commercial exploitation of this stock and should not be used as such unless adjustments are applied for non-reporting of tags. Secondly, tag reporting rates would likely vary between commercial fisheries in Greenland, Newfoundland and Nova Scotia.

SUMMARY AND CONCLUSIONS

1. Wild Atlantic salmon smolts consisted of 91.0% 2-year olds and 6.8% 3-year olds; 2.2% could not be aged.

2. Seventy-eight percent of the wild fish sampled were 1SW salmon; 21.8% were 2SW salmon.

3. Freshwater and saltwater age of hatchery-return salmon were largely dependent on broodstock selection and the number of 1+ or 2+ smolts released.

4. Mean fork lengths and weights of wild and hatchery-return 1SW salmon were 54.0 cm, 1.638 kg and 53.5 cm, 1.546 kg, respectively.

5. Mean fork lengths and weights of wild and hatchery-return 2SW salmon were 73.1 cm, 4.250 kg and 73.4 cm, 4.278 kg, respectively.

6. All salmon regardless of age or stock origin had mean condition factors equal to or greater than 1.000 except for hatchery-return 1SW salmon sampled in 1980-81.

7. Lenght-weight relationships for wild and hatchery-return salmon were calculated using the regression $\ln W = \ln a + b(\ln FL)$.

   The antilogs of these regressions were:

   1SW - Wild: $W = 0.0000597FL^{2.5587}$
   - Hatchery-return: $W = 0.0001312FL^{2.3528}$

   2SW - Wild: $W = 0.0000129FL^{2.9580}$
   - Hatchery-return: $W = 0.0000031FL^{3.2871}$

8. Wild and hatchery-return 1SW salmon consisted of 31.0 and 25.9% females, respectively.

9. Wild and hatchery-return MSW salmon consisted of 71.6 and 66.1% females, respectively.

10. A fecundity-length relationship for LaHave 2SW salmon was described by the equation:

$$F = 78.799e^{0.0592FL} \qquad R^2 = 0.64,\ n = 18$$

11. Two SW salmon with a mean fork length of 74.0 cm produced 6,494 eggs with a mean egg diameter of 5.98 mm and 1,473 eggs$\cdot$kg^{-1}.

12. Upstream migration of 1SW salmon begins in mid-June; the run peaks in early to mid-July. Two SW salmon begin migrating upstream in mid-May; the run peaks in mid to late June.

13. Upstream movements of both 1SW and 2SW salmon are influenced directly by increases in discharge. Both show later migration peaks in mid-September to mid-October coinciding with increased fall discharges; however, these movements are not considered as "late" run components.

14. Based on tag recaptures, an overview of migration routes and timing of salmon movements through the various fisheries is presented.

15. The stray rate for hatchery-return salmon was 1.2%.

16. Adjusted angling exploitation rates for 1SW and MSW hatchery-salmon were 23.6% and 22.7%, respectively.

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Table 1. Morgan Falls trap operation periods, timing and duration of the migration, and numbers of salmon counted.

Year	Fishway trap operation		Salmon migration		Duration of the salmon run (days)	Total number of salmon counted	Adjusted[1] count
	Start	Finish	Start	Finish			
1972	May 1	Nov 3	May 29	Oct 14	139	24	12
1973	Apr 30	Nov 9	Jun 8	Nov 1	147	216	176
1974	May 8	Oct 31	Jun 11	Oct 18	130	633	381
1975	May 9	Nov 17	May 20	Nov 6	171	742	618
1976	May 5	Oct 28	May 18	Oct 22	158	1029	850
1977	May 16	Nov 7	May 24	Nov 1	162	2051	1371
1978	May 17	Nov 10	May 19	Nov 8	174	1332	1112
1979	May 7	Nov 14	May 14	Nov 5	176	3020	2102
1980	May 5	Oct 31	May 12	Oct 31	173	3608	2755
1981	May 15	Oct 30	May 16	Oct 29	167	4695	3563
1982	Apr 26	Oct 29	May 11	Oct 28	171	2328	1908

[1]Corrected for fallback

Table 2. Proportion of salmon sampled at Morgan Falls prior to their release upstream for natural spawning.

Year	Sampling protocol 1SW	MSW	Year	Sampling protocol 1SW	MSW
1974	1:2	1:1	1978	1:15	1:4
1975	1:6	1:2	1979	1:10	1:4
1976	1:10	1:10	1980	1:12	1:7
1977	1:10	1:3	1981	1:9	1:6

Table 3. Smolt-age composition of 1SW and MSW salmon in relation to stock origin at Morgan Falls, 1974-81. (Numbers in parentheses are percentages of the number of one-sea-winter or multi-sea-winter salmon sampled each year.)

Year / Stock Origin	Total number sampled	Smolt-age composition (numbers of fish)												
		1SW					2SW					3SW		
		n	1	2	3	Unknown	n	1	2	3	Unknown	n	1	2
1974														
Wild	10	10		8(80.0)	2(20.0)									
Hatchery-return	165	161	3(1.8)	139(86.3)		19(11.8)	4		3(75.0)		1(25.0)			
1975														
Wild	45	12		6(50.0)	4(33.3)	2(16.7)	33		33(100.0)					
Hatchery-return	104	76	20(26.3)	45(59.2)		11(14.5)	28	2(7.1)	21(75.0)		5(17.9)			
1976														
Wild	69	60		49(81.7)		11(18.3)	9		8(88.9)		1(11.1)			
Hatchery-return	55	6	1(16.7)	5(83.3)			49	17(34.7)	22(44.9)		10(20.4)			
1977														
Wild	74	62		62(100.0)			12		11(91.7)		1(8.3)			
Hatchery-return	49	44	26(59.1)	16(36.4)		2(4.5)	5	1(20.0)	1(20.0)	1(20.0)	2(40.0)			
1978														
Wild	53	29		26(89.7)	3(10.3)		24		22(91.7)		2(8.3)			
Hatchery-return	105	38	29(76.3)	9(23.7)			67	56(83.6)	9(13.4)		2(3.0)			
1979														
Wild	100	83		72(86.7)	10(12.1)	1(1.2)	17		13(76.5)	3(17.6)	1(5.9)			
Hatchery-return	137	98	75(76.5)	19(19.4)		4(4.1)	39	30(76.9)	2(5.1)	2(5.1)	5(12.8)			
1980														
Wild	222	142		136(95.8)	6(4.2)		80		80(100.0)					
Hatchery-return	37	3	2(66.7)	1(33.3)			34	34(100.0)						
1981														
Wild	282	271		241(88.9)	30(11.1)		11		11(100.0)					
Hatchery-return	144	83	74(89.2)	9(10.8)			51	45(88.2)	6(11.8)			10	9(90.0)	1(10.0)
All years														
Wild	855	669		600(89.7)	55(8.2)	14(2.1)	186		178(95.7)	3(1.6)	5(2.7)			
Hatchery-return	796	509	230(45.2)	243(47.7)		36(7.1)	277	185(66.8)	64(23.1)	3(1.1)	25(9.0)	10	9(90.0)	1(10.0)

Table 4. Freshwater and saltwater age composition of wild and hatchery-return salmon sampled at Morgan Falls, 1974-81. (Numbers in parenthesis are percentages of the total number of salmon sampled by stock origin each year.)

		Number of wild salmon							Number of hatchery-return salmon						
		Freshwater age				Sea-winter age				Freshwater age				Sea-winter age		
Year	n	1	2	3	Unknown	1	2	3	n	1	2	3	Unknown	1	2	3
1974	10	8(80.0)	2(20.0)			10(100.0)			165	3(1.8)	142(86.1)		20(12.1)	161(97.6)	4(2.4)	
1975	45	39(86.7)	4(8.9)		2(4.4)	11(24.4)	33(73.3)	1(2.2)	104	22(21.1)	66(63.5)		16(15.4)	76(73.1)	28(26.9)	
1976	69	57(82.6)			12(17.4)	60(87.0)	9(13.0)		55	18(32.7)	27(49.1)		10(18.2)	6(10.9)	49(89.1)	
1977	74	73(98.6)			1(1.4)	62(83.8)	12(16.2)		49	27(55.1)	17(34.7)	1(2.0)	4(8.2)	44(89.8)	5(10.2)	
1978	53	48(90.6)	3(5.7)		2(3.8)	29(54.7)	24(45.3)		105	85(80.9)	18(17.1)		2(1.9)	38(36.2)	67(63.8)	
1979	100	85(85.0)	13(13.0)		2(2.0)	83(83.0)	17(17.0)		137	105(76.6)	21(15.3)	2(1.5)	9(6.6)	98(71.5)	39(28.5)	
1980	222	216(97.3)	6(2.7)			142(64.0)	80(36.0)		37	36(97.3)	1(2.7)			3(8.1)	34(91.9)	
1981	282	252(89.4)	30(10.6)			271(96.1)	11(3.9)		144	128(88.9)	16(11.1)			83(57.6)	51(35.4)	10(6.9)
All years	855	778(91.0)	58(6.8)		19(2.2)	668(78.1)	186(21.8)	1(2.2)	796	424(53.3)	308(38.7)	3(0.4)	61(7.6)	509(63.9)	277(34.8)	10(1.3)

Table 5. Composition of returning salmon (%) in relation to age of wild and hatchery-reared smolts, 1974-81.

Smolt age	Adult composition (%) 1SW	2SW
Wild		
2	0.897	0.957
3	0.082	0.016
Hatchery		
1	0.452	0.668
2	0.477	0.231
3	0.000	0.011

Table 6. Size characteristics in relation to age and stock origin of Atlantic salmon released above Morgan Falls for natural spawning, 1978-81.

Age F.S.	Wild							Hatchery-return						
		Fork Length (cm)			Weight (kg)				Fork Length (cm)			Weight (kg)		
	n	Mean	SD	Range	Mean	SD	Range	n	Mean	SD	Range	Mean	SD	Range
1.1								172	53.2		45.8-59.4	1.525		0.900-2.100
2.1	471	53.9		45.5-62.4	1.633		1.000-2.625	35	54.2		49.0-59.7	1.635		1.125-2.200
3.1	48	54.5		50.2-58.6	1.667		1.050-2.275							
All 1SW[1]	553	54.0	2.63	45.5-63.2	1.638	0.269	0.500-2.625	227	53.5	2.75	45.0-63.3	1.546	0.244	0.900-2.300
1.2								79	73.4		63.4-80.3	4.309		2.550-5.897
2.2	103	72.7		67.1-79.9	4.266		2.650-6.410	6	72.1		62.6-76.4	4.211		2.425-5.200
3.2	3	72.6	4.38	69.6-77.6	4.044	0.524	3.714-4.649							
All 2SW[1]	201	73.1	2.93	66.4-80.4	4.250	0.666	2.650-6.400	87	73.4	3.48	62.6-80.3	4.278	0.807	2.230-5.970
2.2.1	14	62.0		57.2-67.0	2.313		1.850-2.900							
2.3.1	26	76.2		69.2-83.5	4.893		3.700-6.450							
2.4.2	5	88.2		84.2-91.2	8.648		6.875-9.850							

[1]Includes salmon of unknown freshwater age.

Table 7. Condition factors (K) of 1SW and 2SW salmon in relation to stock origin at Morgan Falls, 1978-81[1].

Year / Stock origin	1SW salmon n	1SW salmon Mean	1SW salmon SD	1SW salmon Range	2SW salmon n	2SW salmon Mean	2SW salmon SD	2SW salmon Range
1978								
Hatchery-return	28	1.038	0.0897	0.895-1.252	30	1.085	0.1409	0.466-1.247
Wild	30	1.000	0.1010	0.832-1.251	15	1.163	0.1265	0.881-1.343
1979								
Hatchery-return	97	1.041	0.1112	0.742-1.461	14	1.069	0.1055	0.819-1.207
Wild	85	1.097	0.1138	0.806-1.410	17	1.019	0.0729	0.895-1.147
1980								
Hatchery-return	4	0.971	0.0469	0.924-1.031	8	1.056	0.1134	0.825-1.150
Wild	142	1.068	0.1093	0.715-1.473	85	1.106	0.1295	0.817-1.495
1981								
Hatchery-return	98	0.965	0.0993	0.529-1.220	35	1.067	0.1008	0.909-1.381
Wild	296	1.004	0.1120	0.381-1.591	84	1.057	0.0933	0.871-1.355
1978 to 1981								
Hatchery-return	227	1.005	0.1103	0.529-1.461	87	1.072	0.1164	0.466-1.381
Wild	553	1.035	0.1170	0.381-1.591	201	1.084	0.1165	0.817-1.495

[1] $K = W \times 10^6/L^3$

Table 8. T-statistics obtained by comparing the mean fork lengths, weights and condition factors of wild and hatchery-return 1SW and 2SW salmon sampled at Morgan Falls, 1978-81.

		YEAR									
		1978		1979		1980		1981		1978-81	
		1SW	2SW	1SW	2SW	1SW	2SW	1SW	2SW	1SW	2SW
Length	df	56	43	178	29	145	90	391	118	778	286
	T	-1.406	-1.681	0.122	-1.155	-3.080**	1.121	0.345	2.122	4.485**	-0.303
Weight	df	56	43	178	29	145	90	391	118	778	286
	T	-2.581*	0.311	2.860**	-1.788	-3.395**	1.260	2.163*	1.390	2.385*	-0.777
Condition factor	df	56	43	178	29	145	90	391	118	778**	286
	T	-1.539	1.818	3.395**	-1.568	1.733	0.965	3.102**	-0.396	3.274	0.765

* Significantly different ($P < 0.05$)
**Significantly different ($P < 0.01$)

Table 9. Length-weight relationships for wild and hatchery-return 1SW and 2SW salmon sampled at Morgan Falls, 1978-81 (a = intercept, b = slope).

Saltwater age	Stock origin	n	ln a	a	b	R^2
1SW	Wild	553	-9.7254**	0.0000597	2.5587	0.5395
	Hatchery-return	226	-8.9389**	0.0001312	2.3528	0.5574
2SW	Wild	201	-11.2578	0.0000129	2.9580	0.5567
	Hatchery-return	87	-12.6831	0.0000031	3.2871	0.6111

**Significantly different $P < 0.01$

Table 10. Salmon:grilse and sex ratios of wild and hatchery-return salmon sampled in the spawning escapement at Morgan Falls, 1978-81.

Year	Wild salmon						Hatchery-return salmon					
	MSW			1SW			MSW			1SW		
	n	%F	%S	n	%F	%G	n	%F	%S	n	%F	%G
1978	67	66	20	275	34	80	208	79	27	553	30	73
1979	67	81	7	857	36	93	99	74	9	1079	28	91
1980	287	69	15	1618	29	85	515	59	61	335	26	39
1981	354	73	16	1814	30	84	215	67	15	1180	22	85
Weighted mean		71.6	15.2		31.0	85.8		66.1	39.7		25.9	80.0

Table 11. Proportion of LaHave salmon destined to mature as 1SW and 2SW or older salmon based on the release of tagged hatchery-reared smolts. (Number of tag recaptures are in parentheses).

Recapture location	Age at maturity		S:G ratio (%)	Age at maturity		S:G ratio (%)
	1SW	2SW or older		1SW	2SW or older	
	(From 54,008 tagged smolts released 1974-79)			(From 44,214 tagged smolts released 1976-79)		
Spawning escapement	0.418(278)	0.153(102)	27	0.366(208)	0.162(92)	31
Sport fishery	0.096(64)	0.032(21)	25	0.112(64)	0.033(19)	23
Commercial fishery - NS	0.063(42)	0.069(46)	52	0.074(42)	0.074(42)	50
Commercial fishery - Nfld.	0.060(40)	0.013(9)	18	0.070(40)	0.009(5)	11
Greenland		0.093(62)	100		0.098(56)	100
Unknown		0.002(1)	100		0.002(1)	100
Total	0.638(424)	0.362(241)	36	0.622(354)	0.378(215)	38

Table 12. Fecundity data collected from small numbers of salmon broodstock captured in three Nova Scotia rivers, 1980-81.

Stock origin	Sea-winter age	n	Fork length (cm)	n	Weight (kg)	n	Number of eggs	n	Egg diameter (mm)	n	Number of eggs per kg
Liscomb W	1		50.8		1.361		2,048		5.46		1,505
Liscomb W	1		55.3		1.361		2,338		4.96		1,718
Liscomb W	1		54.6		1.247		2,061		5.10		1,653
Liscomb W	1		53.3		1.247		2,169		5.02		1,739
Liscomb W	1		52.1		1.247		1,467		5.10		1,176
Mean		5	53.2	5	1.293	5	2,017	5	5.13	5	1,558
SD			1.83		0.0624		328.4		0.195		232.4
LaHave W[1]	2		73.4		4.425		6,400				1,446
LaHave W[1]	2		75.0		4.685		7,198		5.21		1,536
LaHave W	2		76.5		5.135		10,051		5.52		1,957
LaHave HR	2		72.5		4.250		6,199		5.62		1,458
LaHave HR	2		77.7		5.010		5,833		5.86		1,164
LaHave HR	2		78.3				8,129		5.36		
LaHave HR	2		76.8		6.075		7,767		5.65		1,278
Medway W	2		68.1				4,160		6.34		
Medway W	2		70.1				5,292		6.44		
Medway W	2		71.1				5,404		6.38		
Medway W	2		74.7				7,527		6.30		
Medway W	2		76.5				5,724		6.17		
Medway W	2		76.7				8,816		6.01		
Medway W	2		76.7				6,324		6.50		
Medway HR	2		66.5				3,895		6.26		
Medway HR	2		72.1				5,025		6.11		
Medway HR	2		74.2				5,697		6.21		
Medway HR	2		75.7				7,456		5.74		
Mean		18	74.0	6	4.930	18	6,494	17	5.98	6	1,473
SD			3.36		0.6537		1,601.6		0.400		273.0
LaHave W[1]	PS[2]		92.5		10.300		12,657				1,228
LaHave HR 1	PS		91.0				12,634		5.70		
Medway W	PS		90.4				11,288		6.72		
Medway W	PS		90.9				13,760		6.81		
Medway W	PS		91.7				11,220		6.17		
Medway W	PS		93.5				10,175		6.47		
Medway W	PS		95.3				13,020		6.50		
Mean		7	92.2			7	12,108	6	6.39		
SD			1.73				1,247.4		0.407		

[1]Broodstock held on well water during the summer.
[2]PS = previous spawners.

Table 13. Recapture of Atlantic salmon at various locations from 54,008 hatchery-reared smolts tagged and released in the LaHave River, 1974-79. (% of total recapture is in parentheses).

Sea-winter age at recapture	Spawning escapement Morgan Falls	Location of recapture: Sport Fish.-NS		Comm. fishery - NS (S.M.Z.)[2]				Comm. fishery - Nfld.					Total tag recaptures
		LaHave[1] River	Other rivers	Atl. Cape Breton	Eastern Shore	Central Nova	Fundy	Labrador	A-F	G-K	L-N	Greenland	Unknown	
Post-smolt	278	2		1		20	1	3	29	6	2	62	1	24
1 sea-winter	97	60	4	10	1	31		1	7	1				486
2 sea-winter	5	19		1	1	43	1							172
Older		2												7
Total	380	83	4	12	2	94	2	4	36	7	2	62	1	689(1.28)

[1]The sport fishery is located downstream from Morgan Falls.

[2]Salmon Management Zone (Statistical Districts):
Zone 5 - Atlantic Cape Breton (Dists. 6-9)
Zone 7 - Eastern Shore (Dists. 14-17, 19)
Zone 9 - Central Nova (Dists. 18, 20-23, 25-27)
Zone 8 - Fundy (Dists. 24, 35, 39-44)

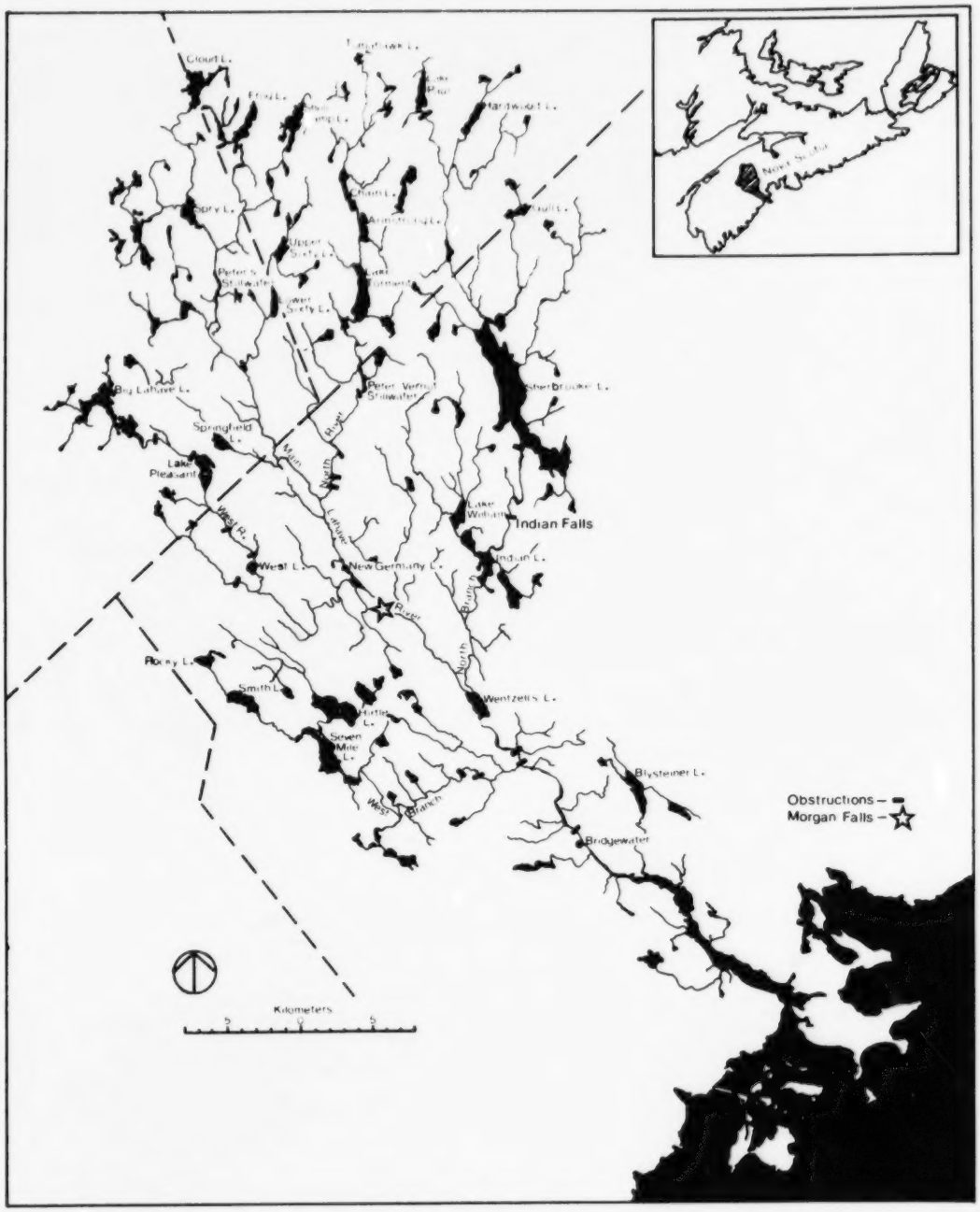

FIG. 1. Map of the LaHave River watershed showing the major lakes, tributaries, obstructions and location of the Morgan Falls fishway trap.

FIG. 2. Morgan Falls fishway and trapping facilities used to sample the upper basin salmon stock.

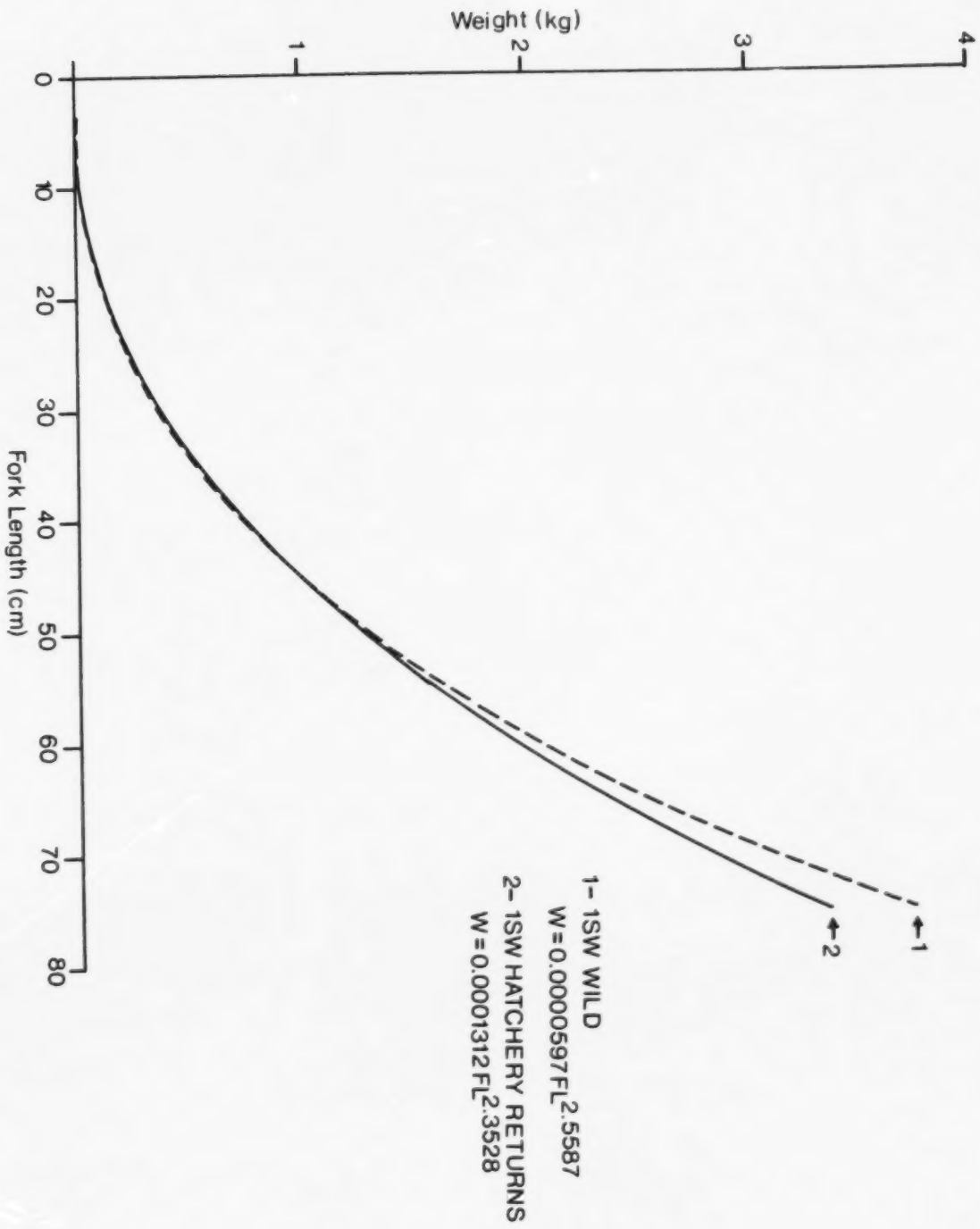

FIG. 3. Length-weight relationship for 1SW salmon of wild and hatchery-return origin, 1978-81.

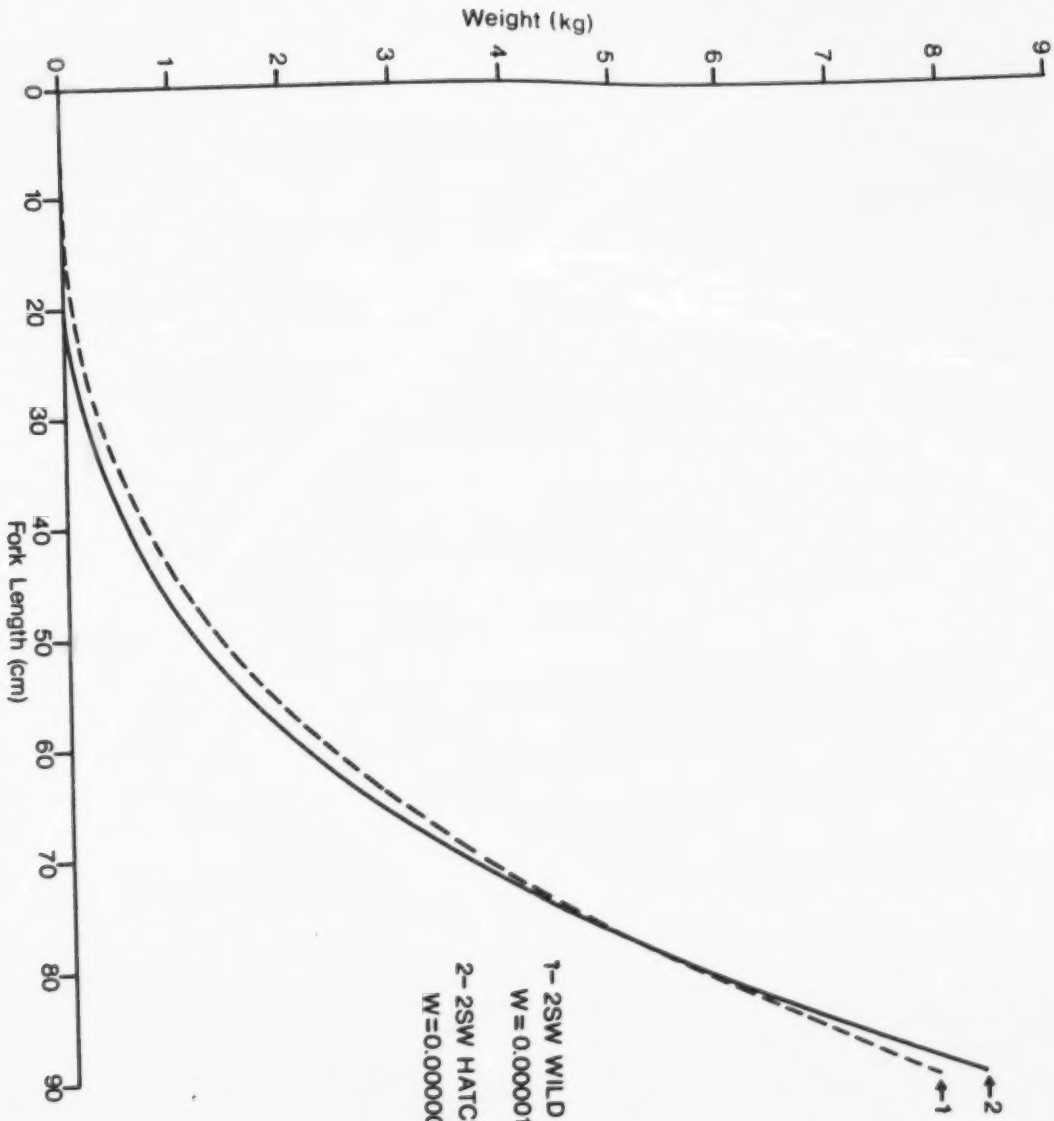

FIG. 4. Length-weight relationship for 2SW salmon of wild and hatchery-return origin, 1978-81.

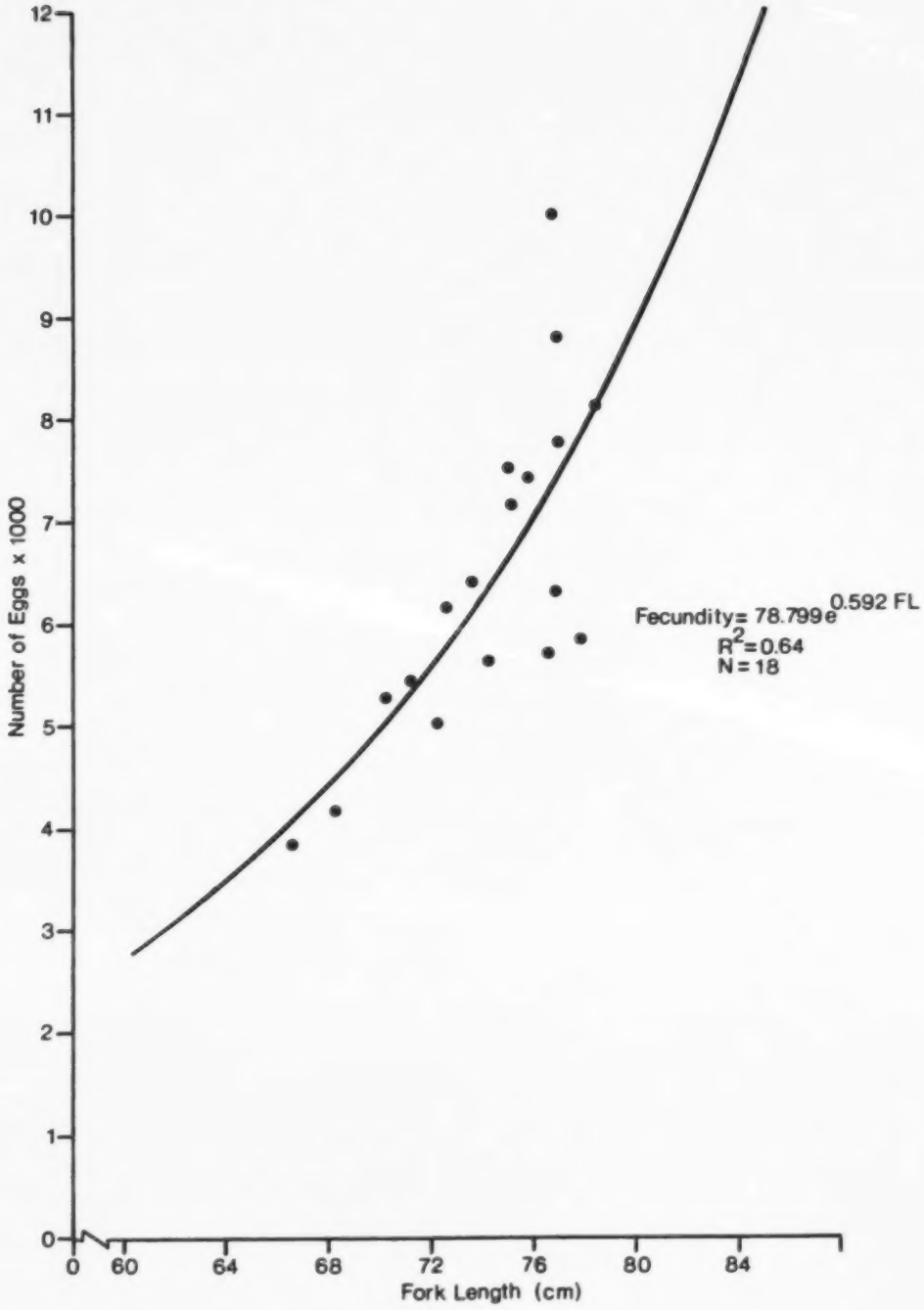

FIG. 5. Fecundity-length relationship for LaHave-Medway 2SW salmon.

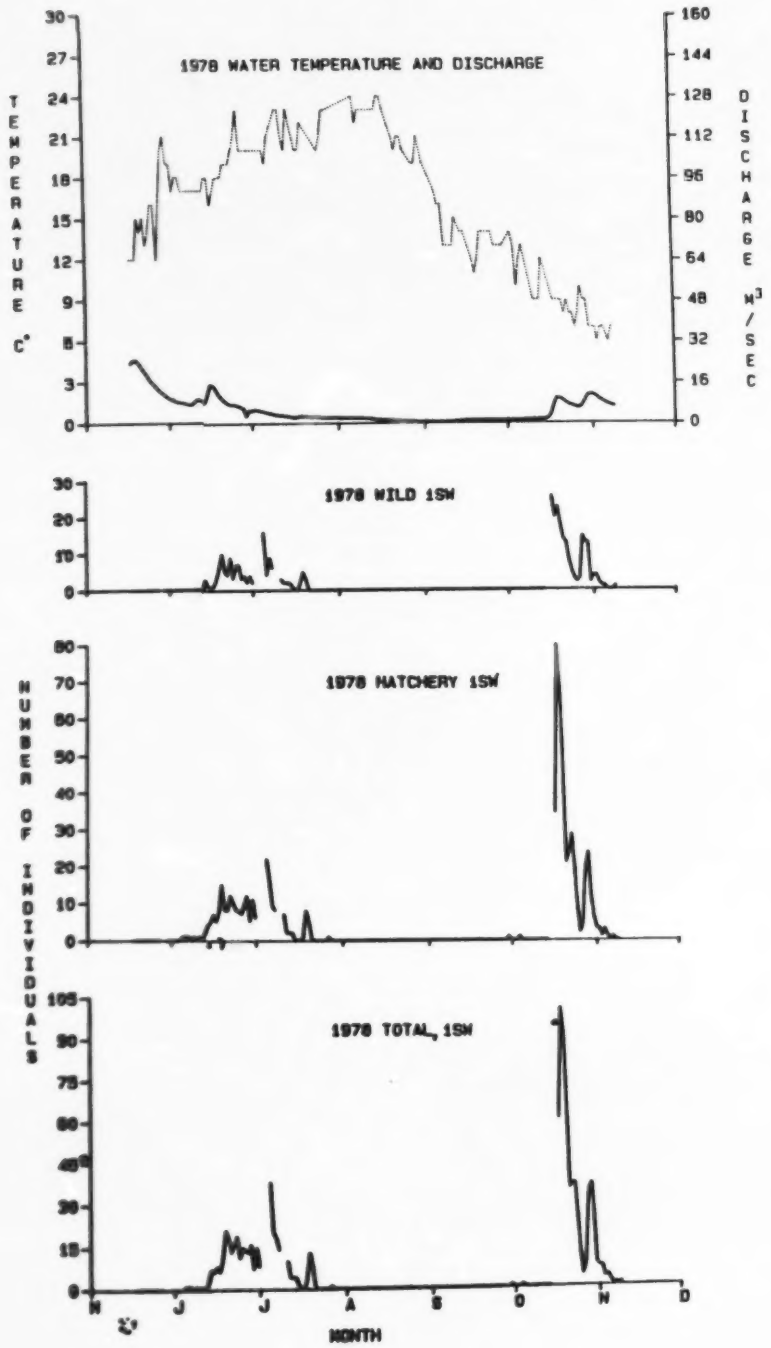

FIG. 6. Number and timing of wild and hatchery-return 1SW salmon at Morgan Falls in relation to water temperature and discharge - 1978.

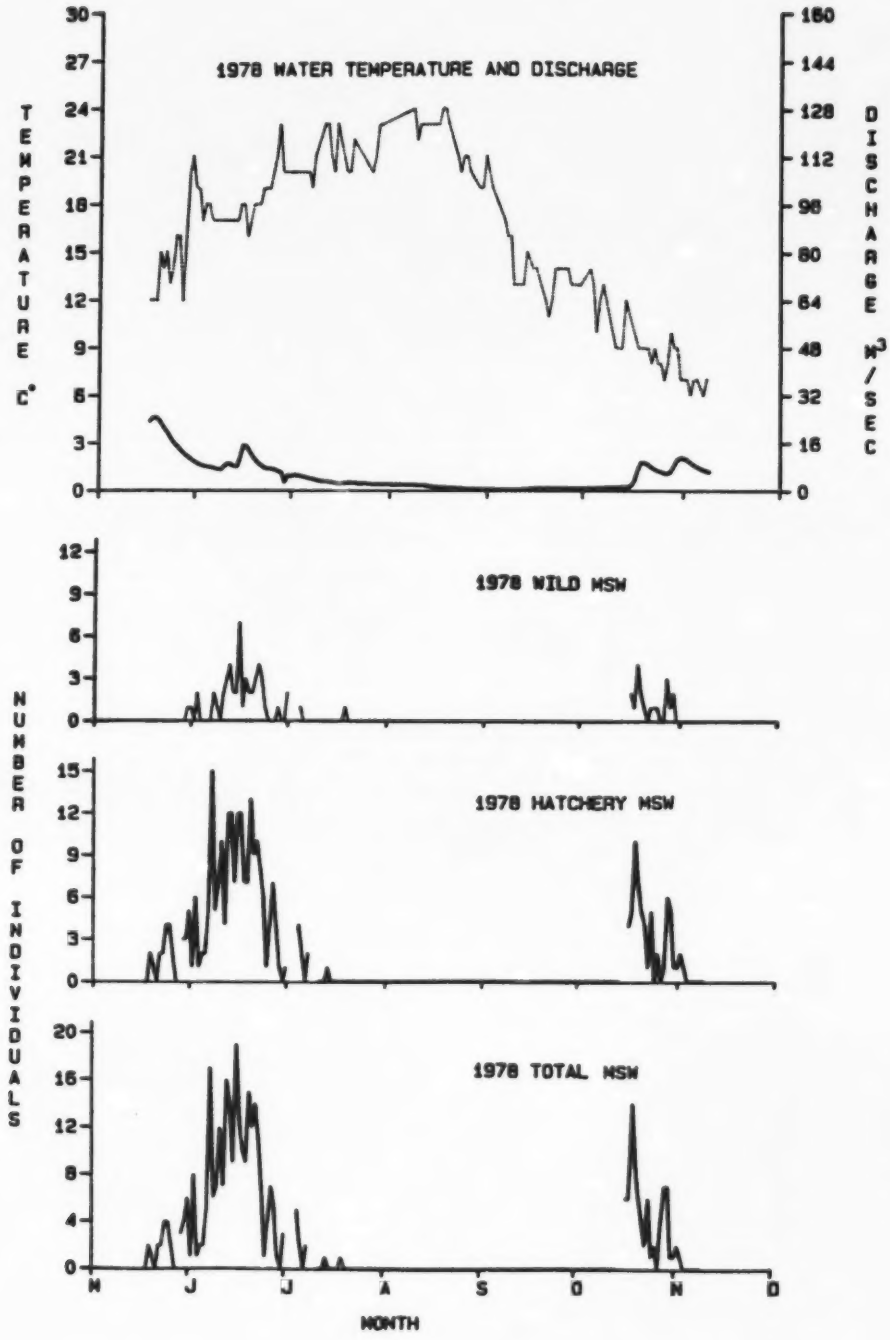

FIG. 7. Number and timing of wild and hatchery-return MSW salmon at Morgan Falls in relation to water temperature and discharge - 1978.

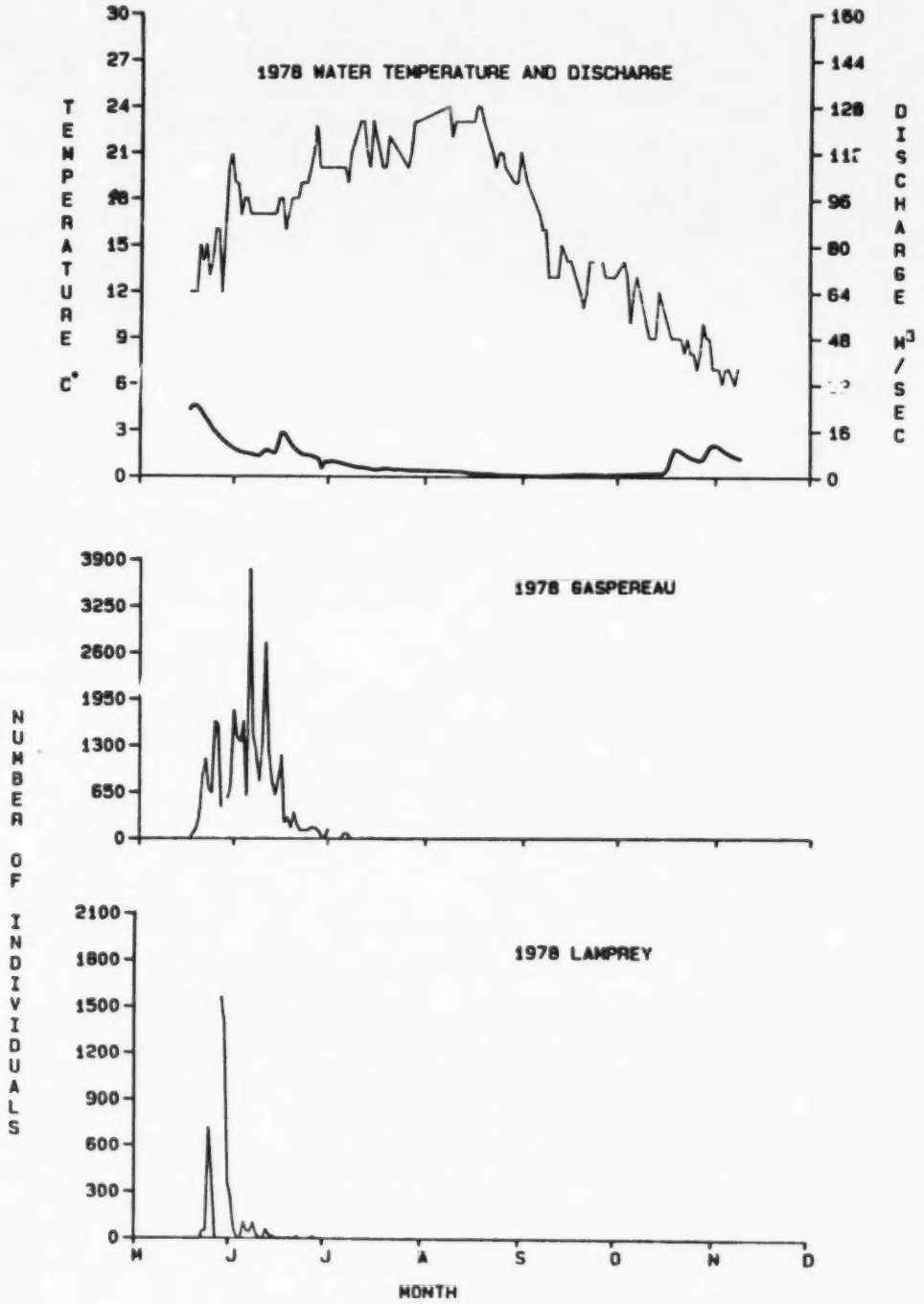

FIG. 8. Number and timing of gaspereau and lamprey at Morgan Falls in relation to water temperature and discharge - 1978.

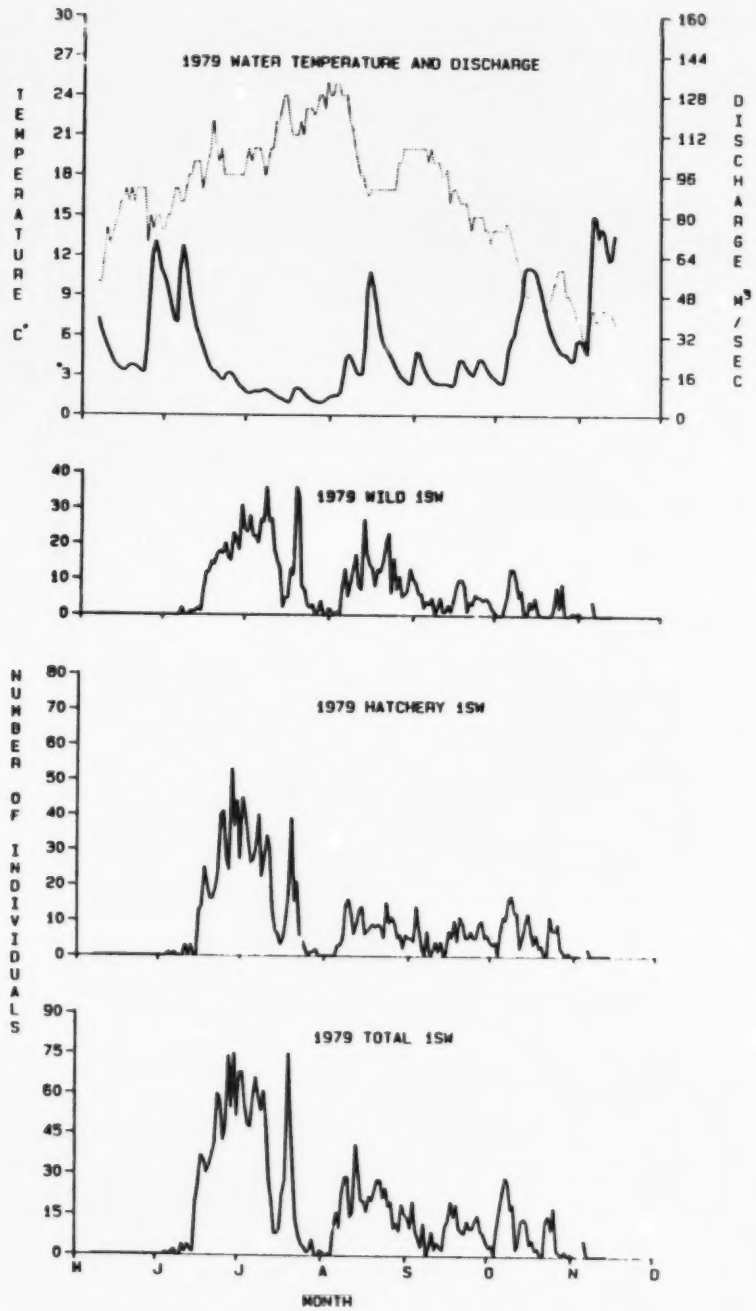

FIG. 9. Number and timing of wild and hatchery-return 1SW salmon at Morgan Falls in relation to water temperature and discharge - 1979.

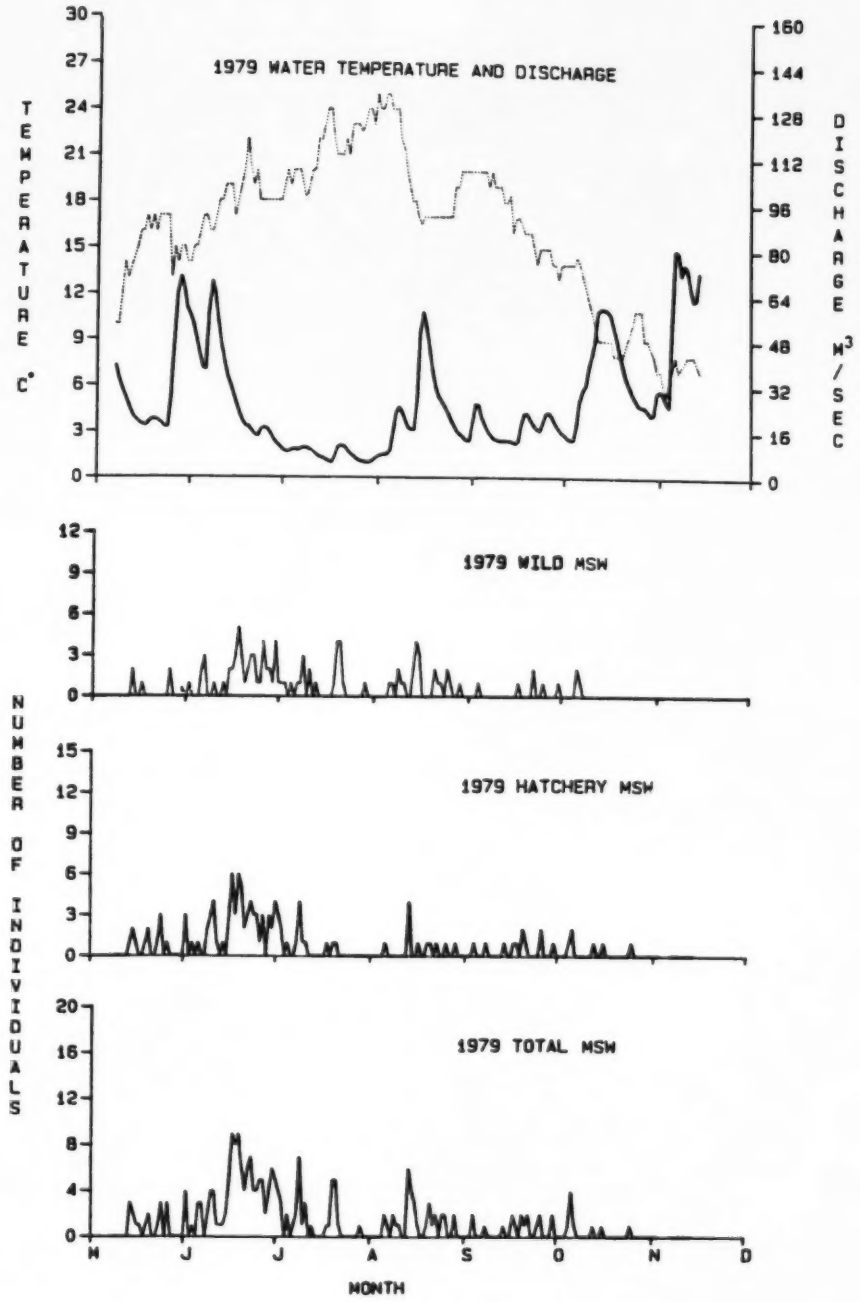

FIG. 10. Number and timing of wild and hatchery-return MSW salmon at Morgan Falls in relation to water temperature and discharge - 1979.

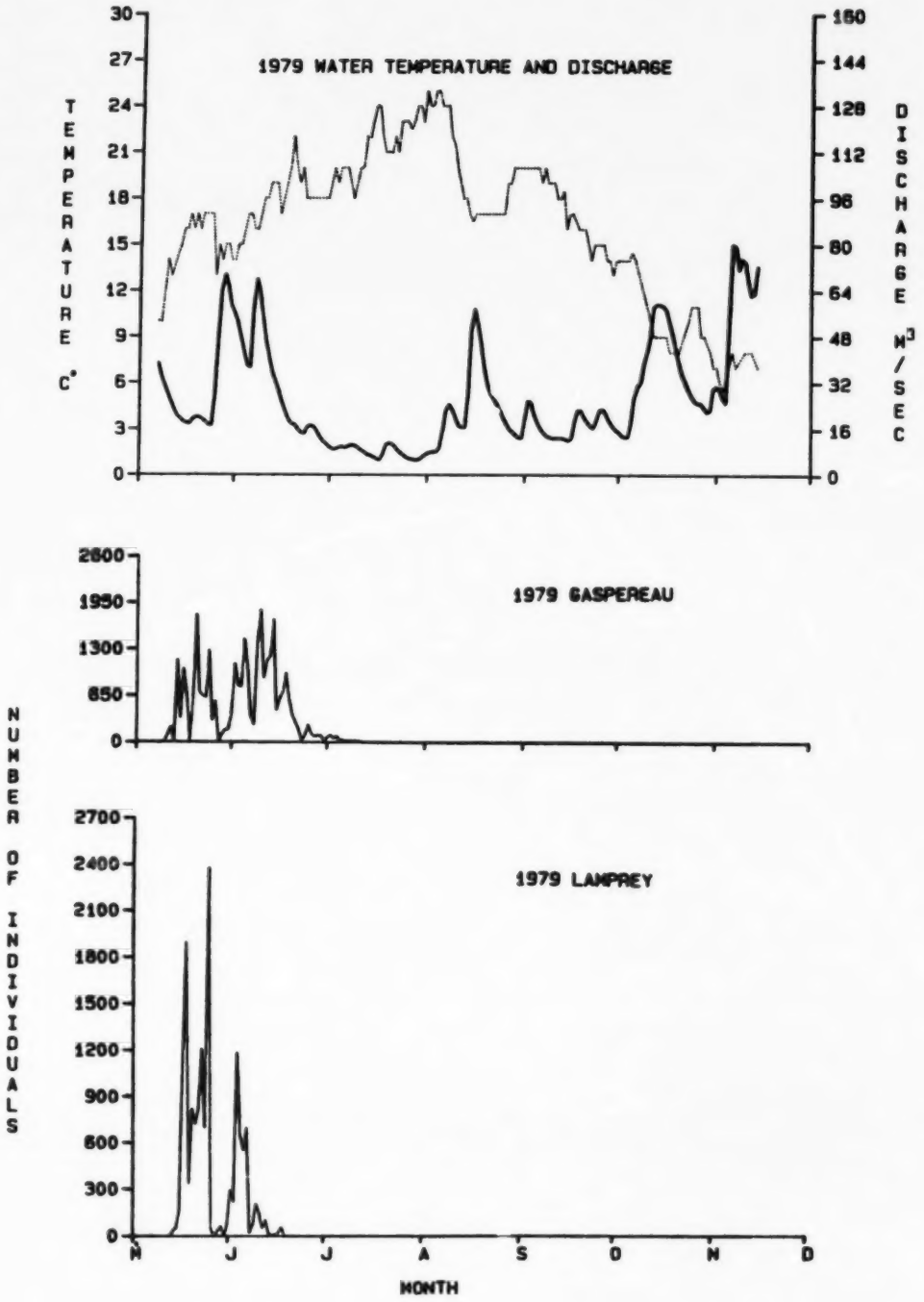

FIG. 11. Number and timing of gaspereau and lamprey at Morgan Falls in relation to water temperature and discharge - 1979.

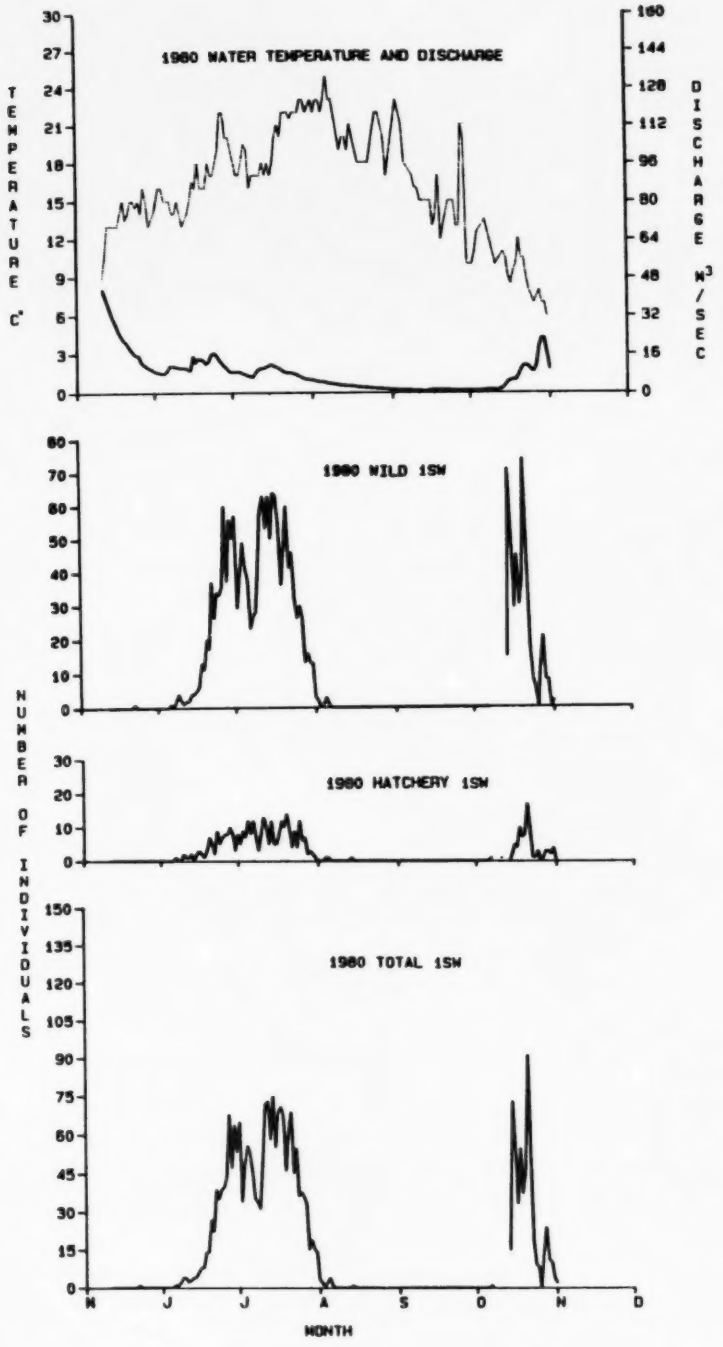

FIG. 12. Number and timing of wild and hatchery-return 1SW salmon at Morgan Falls in relation to water temperature and discharge - 1980.

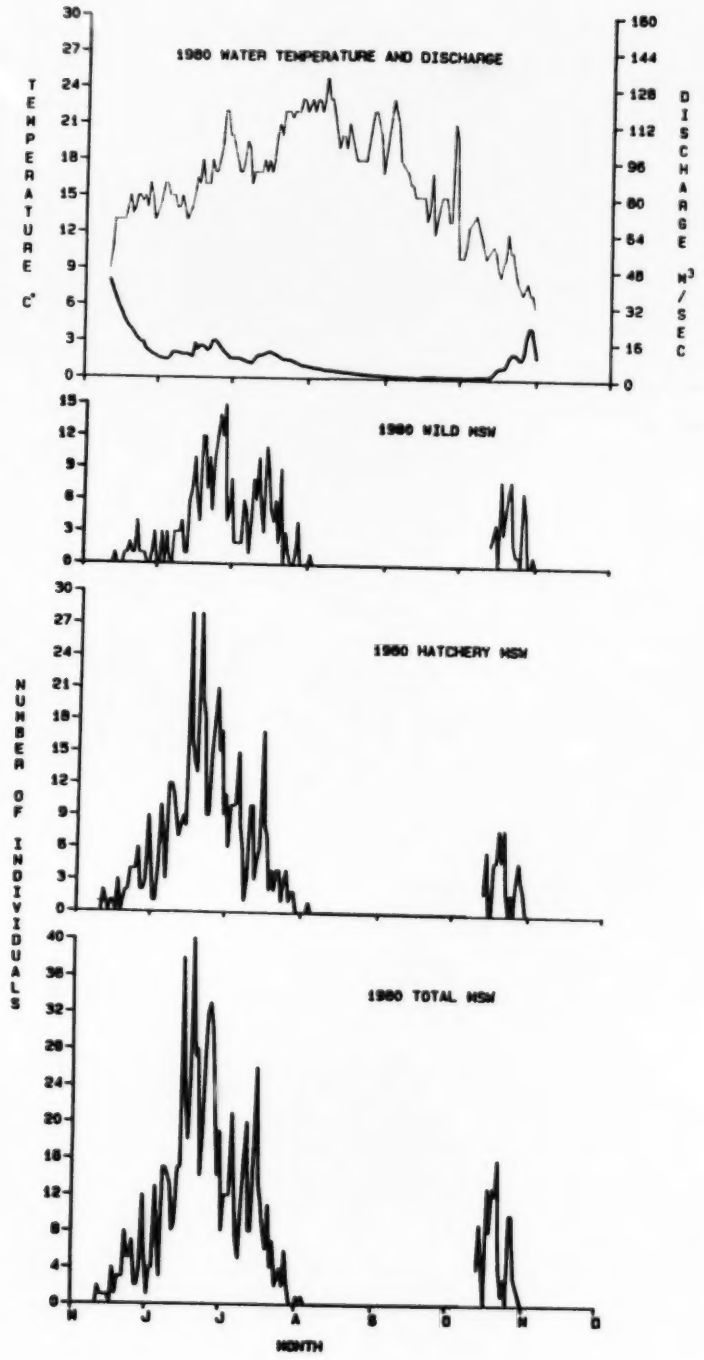

FIG. 13. Number and timing of wild and hatchery-return MSW salmon at Morgan Falls in relation to water temperature and discharge - 1980.

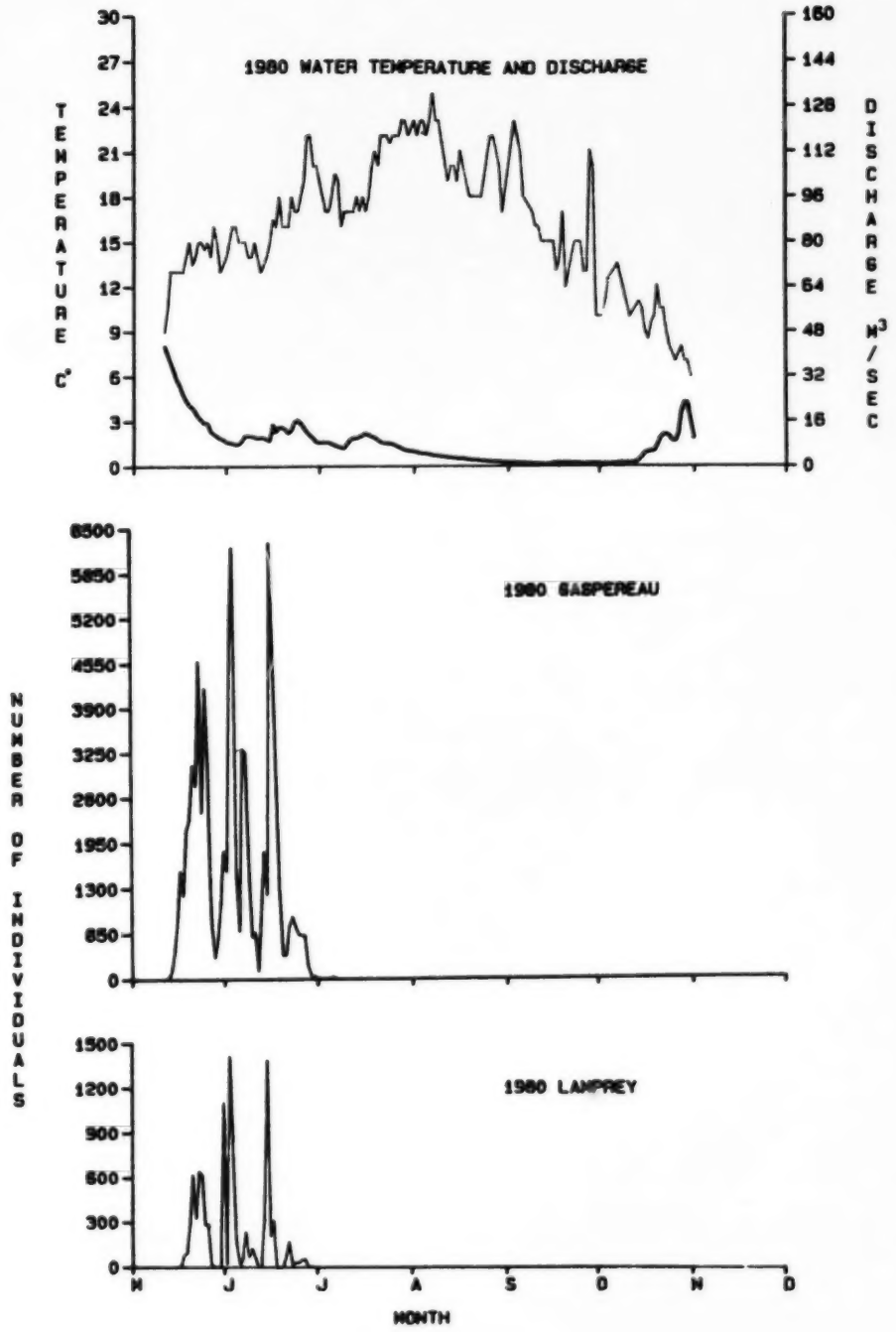

FIG. 14. Number and timing of gaspereau and lamprey at Morgan Falls in relation to water temperature and discharge - 1980.

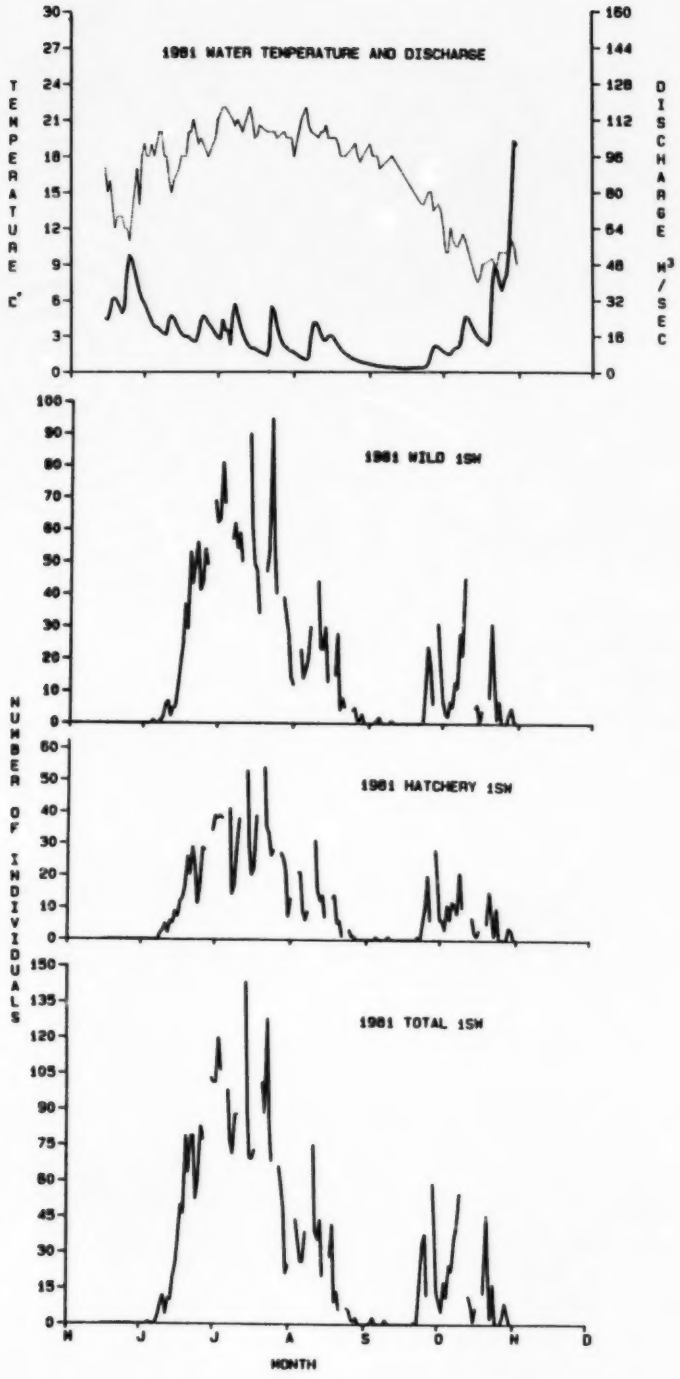

FIG. 15. Number and timing of wild and hatchery-return 1SW salmon at Morgan Falls in relation to water temperature and discharge - 1981.

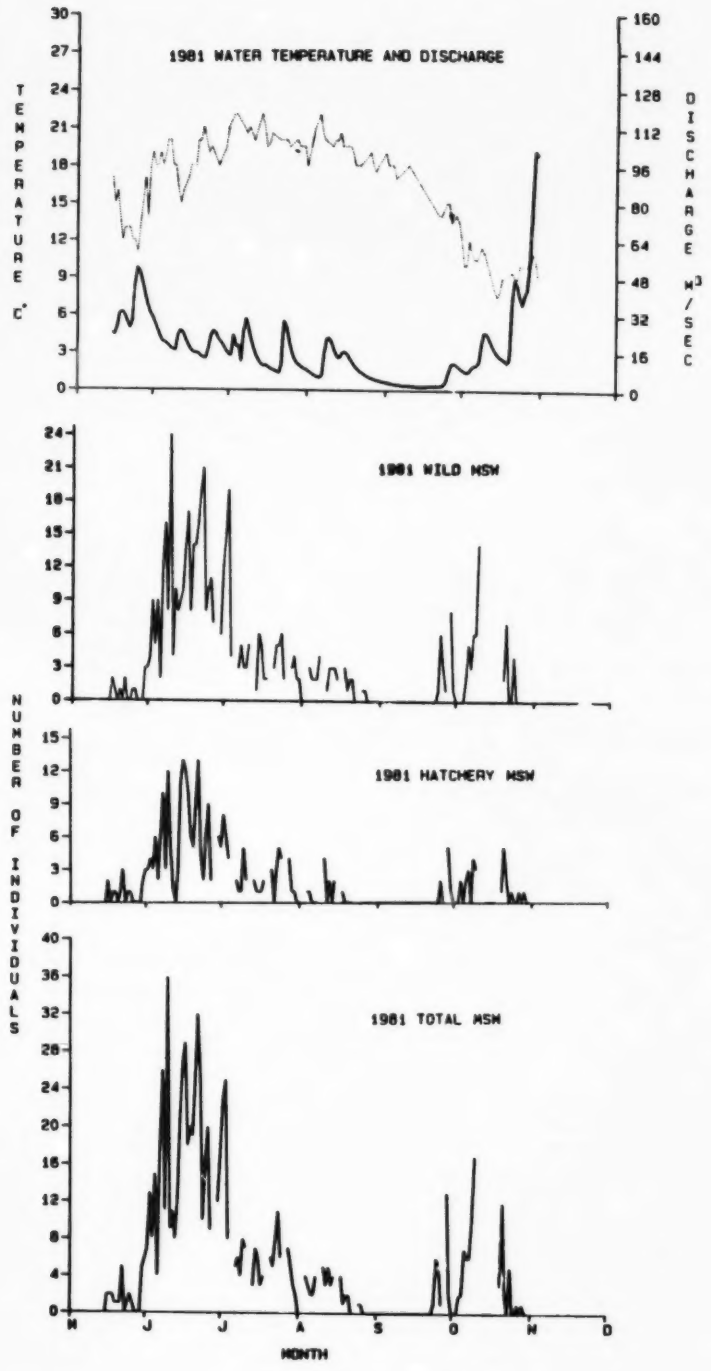

FIG. 16. Number and timing of wild and hatchery-return MSW salmon at Morgan Falls in relation to water temperature and discharge - 1981.

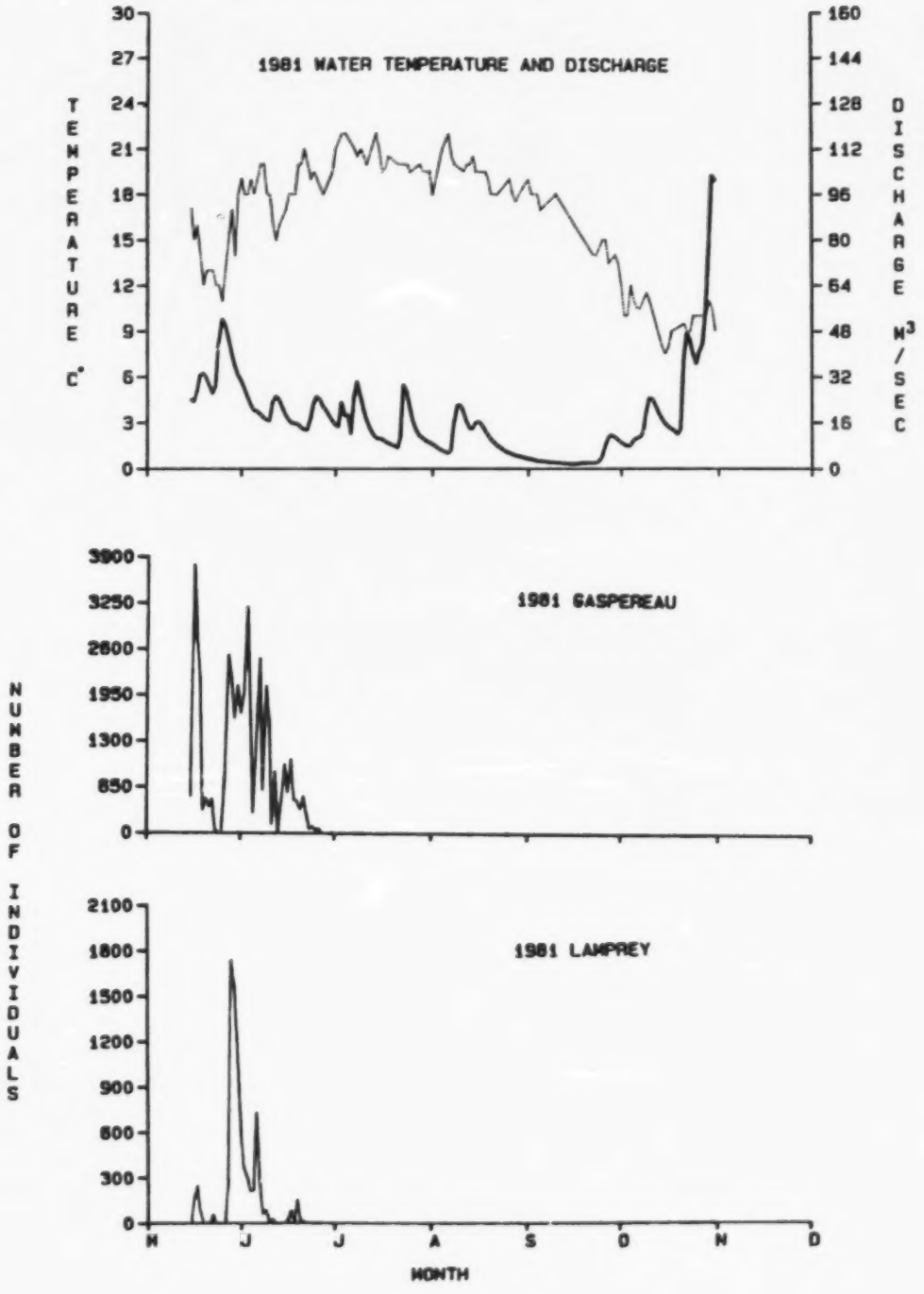

FIG. 17. Number and timing of gaspereau and lamprey at Morgan Falls in relation to water temperature and discharge - 1981.

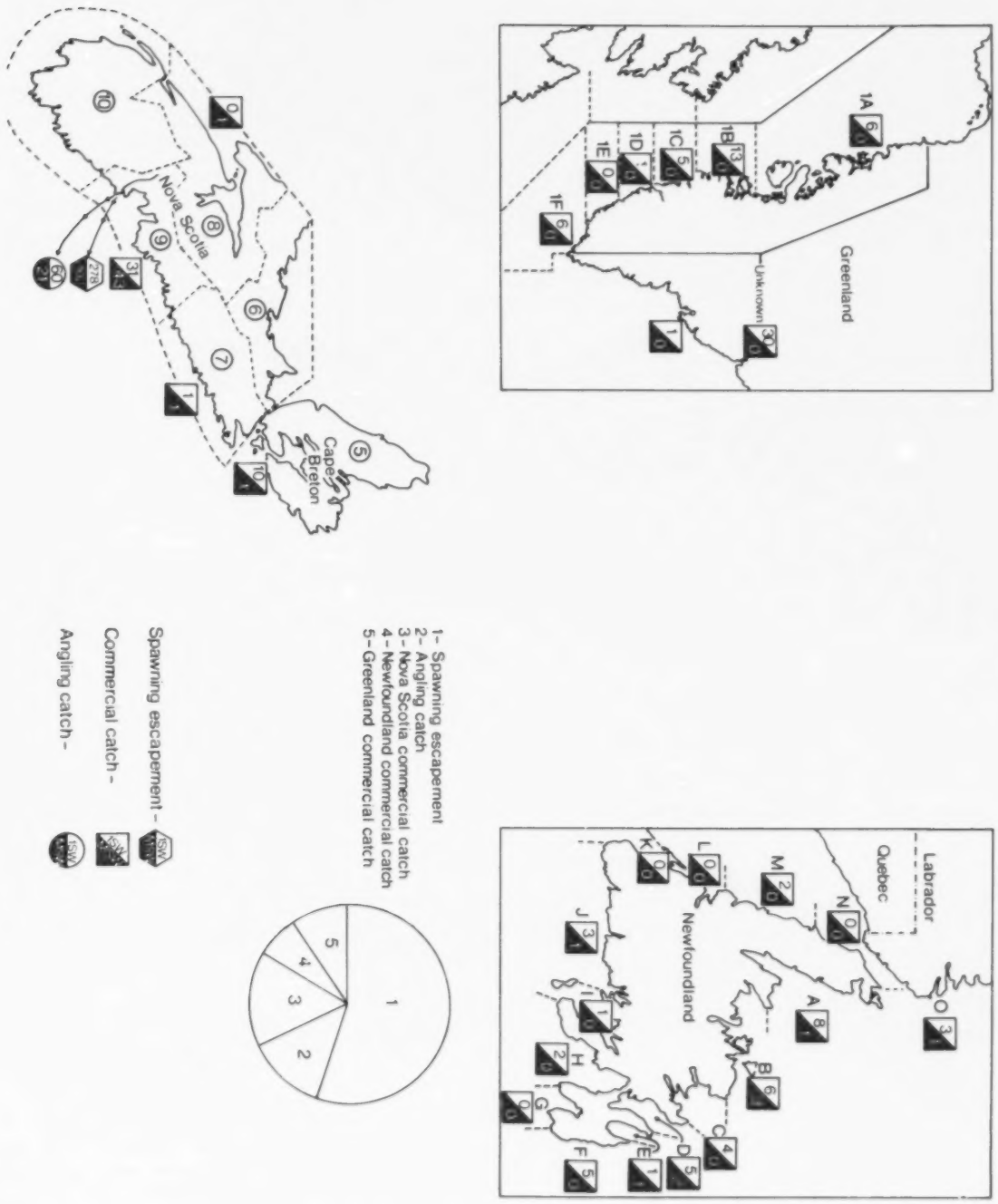

FIG. 18. Location of tag recaptures from tagged hatchery-reared salmon smolts released above Morgan Falls, 1974-79.